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ABSTRACT

This notebook is designed to help educators who are currently learning to design and present inservice programs, educators who are already inservice providers but who might benefit from an overview of inservice theory, and educators who are hiring, supervising, or evaluating inservice providers. It is divided into three parts: (1) Introduction and Background (a short computers-in-education course specifically designed for computer integrated instruction inservice facilitators); (2) Effective Inservice Practices (discussion of what is known about effective inservice and inservice for computer integrated instruction, including the Gall and Renchler report on inservice to promote basic skills, and a literature review focusing on effective staff development for computer integrated instruction); and (3) Evaluation (a variety of instruments for needs assessment, formative evaluation, and summative evaluation of an inservice). References are listed throughout the notebook. (DB)

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EFFECTIVE INSERVICE FOR INTEGRATING COMPUTER-AS-TOOL INTO THE CURRICULUM

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- Chairman of the Association for Computing Machinery's Elementary and Secondary School Subcommittee, 1978-1982.
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Preface

This book is designed to help three types of educational leaders:

1. Educators who are currently learning to design and present inservice for integration of the computer as a tool into the curriculum. These will mainly be well established and quite experienced teachers; they will frequently be school building level computer coordinators or computer representatives.

2. Educators who are already inservice providers, but who might benefit from a overview of some of the underlying theory and ideas of effective inservice practices, as well as from access to inservice evaluation materials.

3. Educators who are hiring, supervising, or evaluating inservice providers for computer integrated instruction.

In addition to specifically targeting the needs of the three types of practitioners mentioned above, the book is firmly rooted in the research literature of effective inservice. The literature surveys and references it contains are useful to graduate students and researchers in the field of effective inservice.

Effective inservice has been a topic of research and writing for many years. There is a large amount of literature on how to design and implement inservice so that it will accomplish its goals. However, most of this literature is quite general in nature. Relatively little of it is based specifically on the problems facing inservice facilitators in the area of integrating the computer as a tool into the curriculum.

I first began to do inservice education in the summer of 1965. It was then that I designed and implemented a course for secondary school math teachers that focused on roles of computer as a tool in the math curriculum. The course was relatively ineffective because I had little knowledge of how to effectively work with inservice teachers. A book such as this would have been very useful to me.

Since then I have designed and conducted a very large number of computer oriented inservice workshops and courses for teachers. Through trial and error (with more errors than I like to admit) I have learned a great deal about how to design and conduct an effective computer integrated instruction inservice. Frequently my work has been supported by grants from the National Science Foundation. During 1985-1989 I received funding from the National Science Foundation specifically to do research and development on effective inservice for integrating tool use of computers into the precollege curriculum. This book summarizes some of the results of my many years of experience, my personal research, and the experience and research of many other educators.

A Map to the Contents of this Book

The overriding goal of this book is to help improve our educational system. This book can help inservice providers as they work to achieve that goal. The book is divided into three major parts.

Part 1 contains general background information that underlies the tool use of computers in schools. In essence, it is a short computers in education course specifically designed for computer integrated instruction inservice facilitators. If you have a solid background in the field of computers in education, you will be able to skip much of this part of the book.

Part 2 focuses on what is known about effective inservice, and in particular about inservice for computer integrated instruction. Most readers will find that this is the heart of the relevant material in the book.

Part 3 contains instrumentation for needs assessment, formative evaluation, and summative evaluation of an inservice. It focuses on the importance of needs assessment, formative evaluation, and summative evaluation in an inservice.

The contents of this book have been extensively tested in a series of inservices on effective inservice conducted during the fall and winter of the 1988-89 academic year. If you have suggestions for additions or revisions, please feel free to contact me.

A number of writers have contributed to the contents of this book as it evolved through the work of the National Science Foundation project that I directed during 1985-89. One large section was written by Gall & Renchler and was originally published by ERIC. Several substantial parts of the book were written by Vivian Johnson while she was a member of the NSF project team and was doing her doctorate research. A number of the ideas in this book were contributed by my graduate students who participated in my seminar on effective inservice. I want to thank all who contributed!

Dave Moursund
April 1989

PART 1: INTRODUCTION AND BACKGROUND

Chapter 1.1
Education for the Information Age

The Information Age

The Information Age officially began in the United States in 1956. At that time the number of people working in a variety of "white collar" service and information-types of jobs first exceeded the number working in industrial manufacturing "blue collar" jobs. Mental power and interpersonal skills were becoming of increasing importance. Clearly the Industrial Age was ending and major change was afoot (Naisbitt, 1984).

Information Age occupations include teacher, grocery store clerk, nurse, bank teller, clerk in a fast food restaurant, data entry clerk, and computer programmer. In some sense, the title Information Age was initially quite a misnomer. The great majority of the change going on was from industrial manufacturing jobs to service jobs. In many cases the change was from jobs providing an upper middle class standard of living into jobs providing a lower middle class or even lower standard of living. It is evident that there is quite a difference in the occupations and pay of a clerk in a fast food restaurant and a skilled worker on an automobile assembly line. It is also important to note that while many of the new jobs required little or no knowledge of computers and their uses, on the average they required a much higher level of education than the old jobs.

Gradually the "Information Age" misnomer has become less of a misnomer. The computer industry was growing quite rapidly in 1956, and has continued to grow. When the Information Age was about 20 years old, the computer industry developed and began to mass produce microcomputers. Gradually microcomputers have become a dominant force in the computer industry. Over the last two years microcomputer sales have exceeded 8 million machines per year in the United States. The microcomputer industry is now larger than the mainframe computer industry. Many of the newer microcomputers have far more compute power than the mainframe computers in use when the Information Age began. Many people now have computers in their homes that are better than the million dollar computers of 1956.

Computers are only one part of the technology that is of growing importance in our Information Age. In 1956 we did not have transistor radios and television sets. We did not have telecommunication satellites and fiber optics. We did not have electronic digital watches and hand held, solar powered calculators. We did not have laser discs for the storage and retrieval of pictures and data. We did not have Fax machines that could be used to rapidly transmit high quality images of a printed page through ordinary telephone lines. We did not have an information explosion, in which the amount of knowledge in some fields such as medicine and computer technology is doubling in less than five years.

What we did have in 1956 was an educational system designed for an Industrial Age society, but with some key holdovers to the Agricultural Age. (The long summer vacation break is a holdover from the Agricultural Age.)

There seems little need to go into detail about key characteristics of an educational system designed for an Industrial Age society. Almost all current educators were educated in such schools, and our current schools are still firmly entrenched in the Industrial Age. A few key characteristics include:

1. Mandatory attendance to a set age, with progress measured mainly by clock hours of attendance rather than by quality and quantity of knowledge and skills attained.

2. Major emphasis on memorization and on providing rapid responses to questions focusing on lower-order skills; not too much emphasis on higher-order skills.

3. Little individualization of instruction; substantial lock stepping of students into same age peer groups.

4. Curriculum that is mainly determined by a relatively small number of textbooks, using a six year adoption cycle, with the books often having quite a long revision cycle.

5. Curriculum that changes very slowly.

6. Individual teachers in self-contained classrooms. Elementary school teachers dealing with 20-30 students, and the entire range of the curriculum. Secondary school teachers dealing with 100-150 students and a narrow part of the curriculum.

7. Substantial emphasis on accountability, with accountability most often being measured by student performance on standardized tests.

Of course, there are some signs of change. For example, at one time it was quite common for a teacher to receive lifetime certification upon completing the standard teacher training program. Now there is a strong awareness that teachers need to be lifelong learners and that their continued certification should take into consideration their continued academic growth. Teachers need to know about computers, telecommunications, and information retrieval systems because these topics are closely related to a number of goals of schools.

Another major sign of change is the large amount of attention that is now being given to higher-order skills and problem solving. Essentially every educational journal and magazine has carried a number of articles on these topics in recent years. Studies that make national recommendations for school change and improvement all pay particular attention to higher-order skills and problem solving. Unfortunately, the impact on the school curriculum has been minimal.

A Staff Development Problem

When the Information Age was beginning in 1956, a few schools had already begun to experiment with instructional use of computers. (Here and in the remainder of this book we use the word *school* to refer to precollege schools.) The development of time shared computers and minicomputers made it less expensive and more feasible for students to be provided with some access to computers. But the real revolution of computers in schools began in the late 1970s as reasonably quality microcomputers became available at a price schools could afford.

Schools have continued to acquire computer facilities. A reasonably large and growing number of students now have quite good access to computers. Many schools have lowered their student to computer ratio to less than 10 and are continuing to add to their computer facilities. In many school districts more than half of the students have good access to computers in their homes.

The emerging high-tech parts of the Information Age are creating a major problem for our educational system. There is a growing gap between the "state of the art" technology as exemplified by technical knowledge and facilities being used in government (especially in the military), business, and industry, and the content and pedagogy of our school system. Our educational system is having a hard time adjusting to the needs of an Information Age society. Our educational system lacks the funds to acquire appropriate high-tech facilities, to revise the curriculum, and to retrain the teachers.

There are no easy fixes to such a problem. Our educational system is massive, well entrenched, slow to change. We have well over 2 million teachers who were educated in Industrial Age schools and who view education through an Industrial Age model. They have spent a lifetime learning to cope with life in an Industrial Age society and to teach in schools designed for an Industrial Age society. Moreover, our teacher education system shares the same characteristics and seems quite slow to change.

Thus, we have a massive inservice education problem. The problem would be difficult to solve even if there were no further changes in technology. But the pace of technological change is quickening. It seems clear that we will not solve the inservice education problem in the near future.

There are many possible approaches to attacking the inservice education problem that we have described. We can work to change the teacher training institutions, so that new graduates are adequately prepared to deal with Information Age technology. We can support curriculum development projects that will lead to curriculum more suited to the needs of people living in an Information Age society. We can acquire computer facilities and other high-tech facilities for use in schools. And, we help our existing teachers and school administrators gain the knowledge and skills they need to be effective in an Information Age school system.

The Purpose of this Book

This book focuses on inservice education of educators who are already on the job. The major focus is on the design and implementation of inservice programs that concentrate on routine and everyday use of the computer as a tool in the curriculum. The purpose of the book is to provide some guidance and support to inservice providers, to help increase the effectiveness of the inservice that they provide.

This book views such inservice providers as the key group of educational leaders who have a good knowledge of our educational system and a good knowledge of the technology that underlies the Information Age. These inservice providers are uniquely qualified educational change agents. If our schools are going to change to be more in tune with our Information Age Society, it is these inservice providers who will lead the way.

Undoubtedly the most effective inservice is done in a one-on-one mode, with a knowledgeable and caring teacher working with a fellow teacher. As we redesign our school system to bring it into the Information Age, we should work to facilitate a great increase in this type of inservice. Every educator should have professional responsibilities of helping other teachers to learn and grow. The everyday work situation of teachers should provide ample time for learning and for helping other teachers to learn. It should be routine for teachers to visit each others classrooms, to observe each others teaching, to work together in learning and implementing new content and pedagogy.

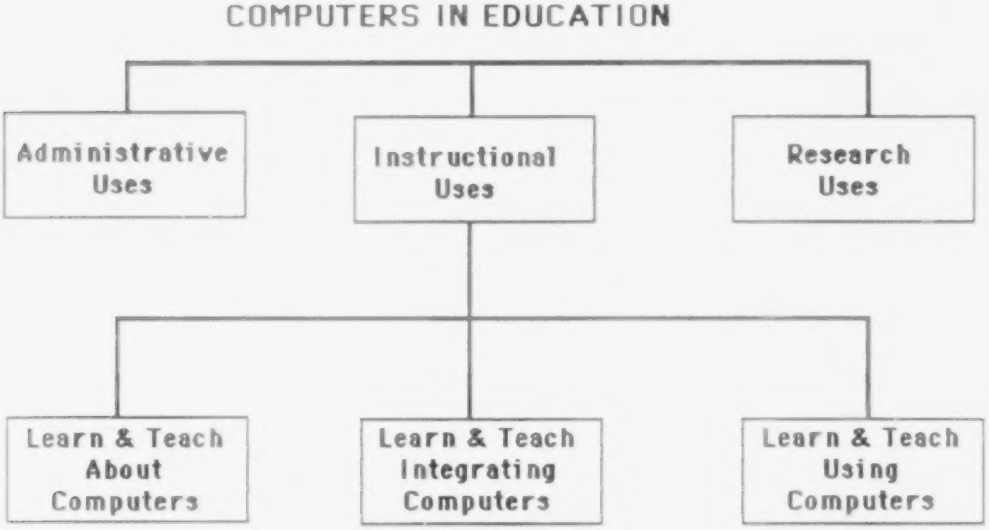
Unfortunately, this situation does not exist in very many of our current schools. The more traditional, large group inservice remains a common vehicle for staff development. This is likely to continue to be the case for many years to come. This book is designed to help make such inservices and their facilitators more effective.

Chapter 1.2
Overview of Computers in Education: What is Computer Integrated Instruction?

The overall focus in this book is on effective inservice for using the computer as a tool throughout the curriculum. The use of the computer as a tool, which we call *Computer Integrated Instruction* (CII), is but one of many possible uses of computers in schools. It is easy for inservice facilitators and inservice participants to get confused among the various educational uses of computers. This chapter provides an overview of computers in education, with primary emphasis on Computer Integrated Instruction (CII). One good use of this chapter is as supplementary reading material for educators participating in a computer inservice.

Computers in Education

The diagram below presents a structure of the overall field of computers in education. As indicated in the diagram, the field can be divided into three main parts. Although each part will be discussed briefly, the main focus is on *instructional uses* of computers. As the diagram illustrates, instructional uses of computers also may be divided into three parts. After briefly discussing each part, we will focus on *learning & teaching integrating computers*. We call this part Computer Integrated Instruction (CII).



Administrative Uses

Many aspects of running a school system are similar to running a business. A school system has income and expenses. It has facilities and inventories. It has employees who must be paid and employee records that must be maintained. And, of course, a school system has students who must be taught. Detailed records must be kept on student performance, progress, and attendance.

Computers can be cost effective aids to accomplishing all of the administrative-oriented tasks listed above. Thus, it is not surprising that computers are extensively used for administrative purposes in most school districts in this country. In some school districts this use goes back more than 25 years. Overall, the administrative use of computers in schools is growing steadily.

At the current time there are two major approaches to administrative use of computers in schools. One approach is based on centralization. A large, centrally located computer system is used to serve a number of schools, as well as central school district office needs. There may be terminals to individual schools. Thus, some input and output operations may occur at the school sites. Other operations especially those involving large amounts of input and output, occur at the central facility.

An alternate approach that has gained considerable support in recent years is to place administratively oriented microcomputer systems into individual schools. Initially these were self-contained microcomputers, but there is a growing tendency to network them. It has become clear that microcomputers can make a substantial contribution to the functioning of a school office.

It seems evident that there will be a continuing need for a central, powerful computer system in most school districts. Also, it seems evident that on-site microcomputers will become increasingly popular. What is not so clear is how and to what extent the central facility and the on-site microcomputers should be networked together, nor is it always evident which computer applications are best accomplished at the school site and which are best accomplished at the central facility.

The design and implementation of a school district administrative computer system is a task for computer professionals. It takes years of computer education and experience to become well qualified at dealing with this type of task. It is important to realize the level of training and experience needed, since few computer using teachers have this type of training and experience. In most school districts the instructional computing coordinator does not attempt to also be the administrative computing coordinator, since these positions require such different types of training and experience.

Research Uses

Educational research has benefited immensely from computers. Many educational research projects involve collecting large amounts of data and subjecting that data to careful statistical analysis. If a research project has a control group and a treatment group, students in the two groups may be tested extensively during various phases of the experiment, resulting in a substantial collection of data. Large libraries of statistical programs have been available for more than 25 years. Now such program libraries are even available on microcomputers. Thus, it is relatively easy for a researcher who is knowledgeable in the use of statistical packages to carry out a number of statistical analyses on the data collected.

Computers are making it easier to conduct longitudinal studies. Detailed records can be kept over a period of years. These records can then be analyzed, looking for patterns or trends that might not be evident under casual scrutiny. This type of research is common in medicine, and some of it has been done in education.

Computer Assisted Learning (which will be discussed later in this chapter) provides an exciting vehicle for research. As students interact with computers while studying a particular subject, the computers can collect and maintain detailed records. These records can be analyzed to help determine which aspects of the instructional program seem to be most effective, and which need

modification. Such formative evaluation can provide the foundation to improve instructional materials.

If a school district is large enough to have an evaluator on its staff, the evaluator is apt to be quite knowledgeable in research uses of computers. It is important to understand that administrative, research, and instructional uses of computers are relatively distinct fields of study. A person may be an expert in administrative uses of computers, yet have little knowledge of the statistical packages and statistical techniques of a researcher. Similarly, a person may be an expert in instructional uses of computers but have little knowledge of the hardware and software needed in an administratively oriented computer system.

Instructional Uses

Our diagram of computers in education divides instructional uses into three categories. The categories overlap to a certain extent, but it is helpful to look at each individually. The first one we will examine is **Learn & Teach About Computers.** Learn & Teach About Computers focuses on the discipline of computer science. (A very broad definition of computer science is used, which includes information science, data processing, computer engineering, etc.) This is a well established discipline; many colleges and universities have had bachelor's degrees and/or graduate degrees in these areas for more than 20 years. There are hundreds of journals and magazines that publish the rapidly growing body of computer related research.

A few high schools began to experiment with teaching computer programming in the late 1950s. This early use of computers in schools provided solid evidence that high school students could learn to program in assembly language or Fortran. However, computers were quite expensive and not particularly accessible for use in high schools.

The development of timeshared computer systems and the language BASIC in the early 1960s opened up the possibility of large number of students learning to write computer programs. As timeshared computers decreased in price, more and more schools began to offer a course in BASIC programming.

By the early 1970s it was becoming clear that computers were beginning to transform our society. The Industrial Age had ended, and the Information Age had begun. Many educators argued that all students should become "computer literate," and that this could be best accomplished through specific computer oriented coursework. Often the courses were in introductory BASIC programming. The trend toward students taking computer programming-oriented courses increased rapidly as microcomputers became available to schools beginning in the late 1970s.

Now a counter trend has emerged as people realize that it is not necessary to learn to write computer programs in order to make effective use of a computer. Many introductory courses have reduced their emphasis on computer programming and increased their emphasis on using applications software that use the computer as a tool. Computer literacy courses have been developed that contain little or no computer programming. Secondary school enrollments in computer programming and computer science courses have dropped markedly.

The rapid growth of applications-oriented computer literacy courses have caused a number of educational leaders to ask why such instruction must be limited to a specific course. Would it be better for students if computer applications were taught throughout the curriculum? The idea is that students should make use of the computer as a tool in all courses where appropriate. That is exactly what Computer Integrated Instruction is about, and it is the main focus of this Notebook. CII will be discussed further later in this chapter.

The teaching of computer programming and computer science courses at the precollege level is slowly beginning to mature. A Pascal-based Advanced Placement course has been developed and is now widely taught. This has tended to lend structure to the high school computer science curriculum. However, it is evident that this type of course appeals to only a small percentage of high school students. Enrollment in introductory programming courses that use BASIC, Logo, or

other non-Pascal-like languages remains high. On a nationwide basis, however, such enrollment peaked several years ago and has declined substantially since then.

Logo has developed a wide following, especially at the elementary school level. Some teachers view the learning of Logo as an end in itself. However, most Logo-oriented teachers recognize the potentials of Logo as a vehicle for illustrating and teaching various problem-solving strategies. The turtle geometry part of Logo also can be used effectively to help students learn a number of important geometric ideas. The *Logo Exchange*, a nine times per year periodical published by the International Society for Technology in Education, is specifically designed for educators interested in using Logo in schools.

Learn & Teach Using Computers. A computer may be used as an instructional delivery device. This type of computer use is often called *computer assisted instruction*, *computer based instruction*, or *computer assisted learning*. In this Notebook it is referred to as ***Computer Assisted Learning*** (CAL).

CAL is sometimes divided into categories such as drill and practice, tutorials, and simulations or microworlds. Most CAL systems include a recordkeeping system, and some include an extensive diagnostic testing and management system. Thus, computer managed instruction is sometimes considered to be a part of CAL.

Initially, most CAL material was designed to supplement conventional classroom instruction. For example, elementary school students might use drill and practice mathematics materials for 10 minutes a day. But as computer hardware costs have declined and more CAL materials have been developed, there is some trend toward implementing substantial units of study and/or entire courses. Declining hardware costs make such CAL use economically feasible. For example, suppose that a small high school has only a half dozen students per year that want to take particular courses such as physics, chemistry, or advanced mathematics. It may be much more cost effective to make such courses available through CAL than through a conventional, teacher taught, mode.

CAL has been heavily researched over the past 30 years. The evidence strongly supports the educational value of using CAL in a wide variety of settings. The success of CAL may be explained by three factors. *First*, students using CAL on the average spend more time on task. Because learning correlates well with time on task, students on the average learn faster using CAL. *Second*, CAL materials allow students to work at their own levels and at their own rates. This individualization is a considerable aid to some students. *Third*, CAL materials can incorporate good practices of instructional and learning theory. Formative evaluation can provide a basis for improving CAL materials under development. Through this approach, the quality of commercially available CAL materials is gradually being improved.

Learn & Teach Integrating Computers. The third category of instructional use of computers is Computer Integrated Instruction (CII). CII focuses on the computer as a productivity tool, an aid to problem solving. One orientation focuses on general purpose or generic application packages such as database, graphics, spreadsheet, word processor, and telecommunications. Each of these application packages is widely used in business, industry, and government. In education, each can be used at a variety of grade levels and in a variety of courses.

A second orientation focuses on the development of applications software for a specific discipline. For example, there is now a substantial amount of software that can help a person compose music. Such software makes possible the teaching of musical composition to elementary school students. There is a substantial amount of Computer Assisted Design (CAD) and other graphics artists software. Such software tools are often now centrally used in high school courses that used to focus on drafting or engineering drawing.

It has long been recognized that precollege students could learn to use computers as an aid to problem solving. The initial approach, now dating back more than 25 years, was to have students learn to write computer programs to solve specific categories of problems. For example, it was suggested that if a math student could write a computer program to solve quadratic equations, this indicated real understanding of that mathematical topic. Over the years there have been a number of research studies on whether this is indeed correct. While the results have been mixed, it seems

clear that having students write computer programs to solve math problems is not a magical solution to the problems of mathematics education that our schools face.

Initially, such an approach to CII made little progress because both the programming languages and the computer hardware were not suited to the needs of most precollege students. But the advent of timeshared computing and BASIC have helped to change that. And then, beginning in the late 1970s, microcomputers, with built-in BASIC, made it feasible for millions of students to learn to write simple programs to solve specific categories of problems.

It takes considerable time, as well as a specific type of talent, however, to become a competent computer programmer. It was soon recognized that the time was being taken away from the study of conventional subject matter. The movement toward integrating computer programming into various high school courses has long since peaked and has been replaced by a trend toward using applications packages. This new trend has accelerated as better applications packages have become available for microcomputers used in schools. An increasing percentage of this software is specifically designed for use in education.

Word processing can be used to illustrate both the general idea of CII and some inherent associated difficulties. Word processing is a generic computer application tool in the sense that it is applicable across the entire curriculum at all grade levels. Clearly, a word processor is a cost effective productivity tool for secretaries and for many people who do a lot of writing. Moreover, word processors make it easier to do process writing (prewrite, compose, conference, revise, and publish). For these reasons, many schools have decided to have all their students learn to do process writing in a word processing environment.

But it takes quite a bit of instruction to learn to make effective use of a word processor. To learn proper keyboarding techniques and to keyboard faster than one can handwrite takes a typical fourth grade student about 30 minutes a day for eight weeks or more. To learn to compose at a keyboard and make effective use of a word processor takes additional instruction and practice.

There are several additional difficulties. First, teachers have to learn to provide the initial instruction and to work with students who do process writing in a word processing environment. Even if the initial instruction is provided by a specialist rather than the regular classroom teacher, the classroom teacher must work with students after the initial instruction. All of the students' subsequent teachers face the same problem. This suggests that large numbers of teachers will need to learn to work with the idea of process writing in a word processing environment.

Second, there is the matter of access to appropriate computer systems. Once a student becomes adept at this mode of writing, the student will want to continue its regular use. This can easily require providing each student with 30 minutes of computer time per day. It also raises the issue of needing to provide computer access for students to use at home, after school, and on weekends.

Third, there is the problem of testing—especially standardized testing. Suppose a student has had several years' experience in using a word processor to do process writing. The student has learned to approach writing projects using this productivity tool. There is a good chance the student can write better and faster using a word processor than using pencil and paper. An appropriate assessment of this student's writing skills requires giving the student access to a computer during the test.

Fourth, once one has a word processor, it is quite helpful to have a spell checker, a grammar/style checker, and an outliner. Such aids to writing may have a significant impact on the nature of the writing curriculum. They may require changes in textbooks, lesson plans, and the way class time is structured. And once again the issue of testing arises. Should a student be allowed to use spelling and grammar checkers when doing writing for an essay test?

These four types of difficulty occur for all CII applications. The problem of teacher training is addressed specifically by the materials in this Notebook. The problem of access to appropriate hardware and software will be with us for many years to come. It can be overcome through appropriate allocations of money. The testing problem is being addressed by a number of agencies involved in widespread assessment. For example, some states and provinces now allow use of calculators on certain tests. However, it seems clear that this will be a long term problem. Textbook companies are slowly beginning to address the issue of integrating the computer as a tool

into the books they publish. School districts and individual teachers interested in making more rapid progress are developing their own curriculum materials.

The Potential of CII

Many work environments now provide a computer or computer terminal for every employee. It is clear that this will become more and more common, because computers are such useful aids to solving certain types of problems and increasing human productivity. Thus, it seems appropriate to assume that increasing numbers of today's students will use computers when they go to work.

Research on transfer of learning strongly supports the position that instruction and training should closely parallel the final desired behaviors. Thus, if we need workers who are adept at using computers to aid in solving problems, we should integrate computer use as students develop their basic problem-solving skills and strategies. For these and other reasons, it seems clear that CII will grow rapidly for many years to come.

As CII increases, both teachers and students will begin to question the content of many of their courses. If a computer can solve or help solve a particular type of problem, what should students learn about the problem? Is it necessary and appropriate to learn to solve each type of problem using only conventional aids such as books, and pencil and paper? Or, should schools focus more on underlying concepts and help students gain an overall understanding of problems that computers can solve?

In some cases an answer will be forced on schools. For example, libraries are being computerized. Card catalogues are being replaced by computerized information retrieval systems. Important publications are available only in computer databases. Since learning to access information is an essential component of education, students will have to learn to use databases and computerized information retrieval systems.

In other cases schools will have wide options. For example, consider the impact that handheld calculators have had on the upper elementary school and middle school mathematics curriculum. While the potential for calculator-integrated instruction is large, the actual impact on the curriculum has been minimal. This is true in spite of many years of strong support from the National Council of Teachers of Mathematics for integration of calculators into the curriculum. In April 1986, the NCTM issued still another strong statement recommending calculator use at all grade levels. A few states and provinces are now beginning to allow use of calculators in certain testing situations. We may be seeing the beginnings of a trend toward allowing calculators (and, eventually, computers) in standardized testing situations. During the academic year 1987-88, for example, the Chicago public schools purchased approximately a hundred thousand calculators for use by their students.

Much of the short term potential for CII depends on how well our educational system addresses the issue of inservice education. All current teachers can learn to make effective use of CII. Given appropriate inservice educational opportunities, many will do so.

Chapter 1.3
Roles of Computers in Problem Solving

Problem solving lies at the heart of an educational system designed for the Information Age. Moreover, computers are a unique new aid to problem solving. Thus, much of the inservice education needed to help teachers move into the Information Age should focus on a combination of problem solving and computer applications. Every computer inservice facilitator should have a clear understanding of roles of computers in problem solving. Often an inservice will focus on a particular computer application, such as a word processor, database, or spreadsheet, that is designed to help solve certain types of problems. This chapter is a suitable handout for participants in such an inservice.

Each academic discipline focuses on certain types of problems. Each discipline has vocabulary and notation, methodology, and tools to aid in describing and solving its problems. Problem solving is a unifying theme throughout all of education. In this chapter we use the term *problem solving* in a very general sense, so that ideas such as higher order skills and thinking skills are also included.

Undoubtedly the single most important idea in problem solving is that of *building on the previous experiences of oneself and others*. For example, consider the importance of language in problem solving. The language(s) you speak and read have been developing over many years, beginning long before you were born. You learned to speak and read many years ago, so that now when you speak or read you are using learning work that you did long ago as well as building on new meanings words have taken on for you.

Paper and pencil provides another type of example of building on the previous work of oneself and others. It is evident that paper and pencil are useful aids to problem solving in every discipline. Paper and pencil artifacts are developed and produced by people. When you use these artifacts, you are building on the work of the inventors, producers, and distributors of these artifacts. Paper and pencils are tools that you spent many hours learning to use when you were young. You now use them readily and with little conscious thought of your earlier learning efforts.

The Computer Tool

Now we have a new, general purpose aid to problem solving. (Actually, the electronic digital computer was invented in the 1940s, so it really isn't very "new" anymore. Commercial mass production of computers began in 1951 with the introduction of the UNIVAC I. Most people who talk about the computer being a new tool are people who have been introduced to computers recently. The computer is new to them, so they assume it is new to others.) The advent of the microcomputer beginning in the mid-1970s has made computers readily available to very large numbers of students and workers. However, it is only recently that enough computers have been made available to precollege students to begin making an impact on their education. In that sense, computers are still a new tool in education.

One of the most important ideas in problem solving is that the aids available for solving a problem shape the thinking processes used. You have grown up with books and pencil and paper. When you were a young student, you received many years of instruction in their use. Now, when working on a problem, you automatically consider possible uses of these aids.

For example, suppose that you needed to prepare lesson plans for a course. Perhaps you would first do some brainstorming, writing notes to yourself on the major ideas to be covered, sources of information, timelines, and so forth. Next, you might go to your files and pull out materials you have collected and/or used in the past. Then you might begin to organize, writing

new materials and adding to old materials. Perhaps a trip to your bookshelf or the library might be necessary. Finally, you might put it all together in a notebook or in file folders.

This description represents a problem-solving process. It involves careful thinking, drawing on one's knowledge of students, one's own teaching skills, the teaching/learning process, school schedules, etc. It involves creating new materials and reorganizing old materials. It involves information retrieval, organization, processing, and storage. In this problem-solving process you automatically, and with little conscious thought, make use of reading and writing. The reading/writing tools, which are actually essential to solving the problem, are essentially transparent in the problem solving process. That is, you don't even think about them. Eventually it will be this way with computers, and that is a major goal for computers in education.

A computer can be a useful aid in accomplishing much of the work in solving the lesson planning problem discussed above. However, relatively few people have worked with computers long enough for computer use to be second nature. Indeed, it could well be that most adults today will never achieve this level of comfort or ease in using computers. But students who have the ability to learn reading and writing can also learn how to use the computer as a problem-solving tool. This can be done through computer integrated instruction which focuses heavily on the computer as an aid to problem solving.

Because computers are still rather scarce in elementary schools, the idea that students may grow up accustomed to the idea of using the computer as a tool may seem rather "far out" to you. But on a national scale we are now in a period of very rapid growth in availability of computers in schools. The value of learning to use a computer with a word processor, spelling checker, and grammar checker is now widely accepted by educational leaders. Many school districts have made the decision that all their students should have such an educational opportunity. Often these school districts are also teaching their students to make use of databases and computer graphics. Eventually these types of problem-solving tools will be a routine part of the elementary school environment as well.

A Definition of a Formal Problem

Every person encounters and copes with a large number of problems every day. Many of these problems are routine and solving them becomes almost automatic. But think for a moment about the variety of problems you deal with in a typical day on the job. For example, as a classroom teacher, you routinely solve problems such as deciding what materials to teach, how to present them to students, how to measure student performance, and how to work with students who are not performing up to your expectations. You attend staff meetings and work on problems faced by the whole school. You handle your personal budget, solving problems on how these funds should be used. It is easy to extend the list, and you should find little difficulty in building your own list. This exercise should convince you that you are an accomplished problem solver and know a great deal about problem solving.

Problem solving has been carefully studied by many great thinkers. There are a number of books that define the concept we call *problem* and explore a variety of problem-solving techniques (see the references listed at the end of this chapter). We will use the following four components as a definition of problem:

1. **Givens.** There is a given initial situation. This is a description of what things are known or how things are at the beginning.

2. **Goal.** There is a desired final situation (or more than one). This is a description of how one wants things to be; it is a description of the desired outcome.

3. **Resources.** This is a listing or description of the general types of steps, operations, or activities that may be used in moving from the Givens to the Goal. Resources are the empowerment and facilities—that is, the powers of the problem solver, or the conditions that must be adhered to as one attempts to solve the problem. (The Resources *do not* tell one how to solve the problem.)

4. **Ownership.** In order for something to be a problem for you, you must accept some ownership. You must be interested in solving the problem or agree to work on the problem.

The choice of vocabulary (Givens, Goal, Resources) is not completely standard; other writers may use different terms. When we say that a problem is *well defined*, we mean that the Givens, Goal, and Resources are clearly and carefully specified. A well-defined problem can be worked on by people throughout the world over a period of time. Progress toward solving the problem can be shared, and cumulative progress is possible. This idea of sharing progress toward solving a problem or category of problems is absolutely fundamental to the human race making intellectual progress.

We frequently encounter problem-like situations that have some, but not all, of the four defining characteristics of a formal problem. We will call these *problem situations*. Often the most important step in solving a so-called "problem" is to recognize that it is actually a problem situation and then do the work necessary to obtain a carefully defined problem. This requires careful thinking, drawing on whatever knowledge one has that might pertain to the problem situation. Often a group of people will have a brainstorming session to get relevant ideas. See especially the works by Torrance. His research and development group has produced instructional material designed to help students gain improved problem-solving skills. See also de Bono (1971, 1973).

Each of the four components may require further explanation in order to become clear to you. We begin with the last one: **Ownership**. Some experts on problem solving exclude this component, while others give it considerable weight. If coping with a particular situation is essential to your survival, you are apt to have considerable ownership of this situation. But if the situation is a hypothetical (school book) exercise of little intrinsic interest, you may have little or no ownership. Ownership is a mental state, so it can quickly change.

Ownership in problem solving is a key idea for Information Age education. Education would be much better if students took more responsibility for their own learning—if they had increased Ownership of the problem of acquiring an adequate education. Individualization of instruction requires giving greater freedom and the ability to take the initiative to the person being educated.

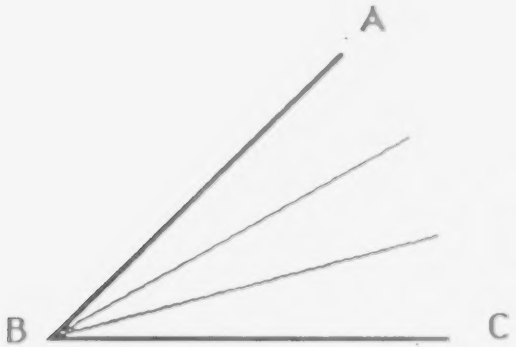
The issue of ownership is particularly perplexing to educators. They recognize that ownership —that is, a deep interest and involvement with a situation—often contributes to deep and lasting learning and intellectual growth. Thus, teachers often expend considerable effort creating situations in which their students will feel ownership.

Some alternatives to ownership are *apathy* and/or *coercion*. Keep in mind that problem solving is a higher order mental activity. Most people do not perform higher order mental activities well under coercion or while in a "I couldn't care less" mood.

As an aside, you may know some students who have spent literally dozens or even hundreds of hours working on a particular computer program or mastering a computer system. You may have said to yourself, "If only I could get all of my students that deeply involved." It is clear that such ownership of a computer related problem has changed the lives of a number of very bright and talented students.

Many people are puzzled at first, by the Resources component of the definition of problem. Suppose that you were giving your students a spelling test. From the student viewpoint, the task of correctly spelling a word is a problem to be solved. The student would be successful if allowed to use crib notes or a dictionary. What makes the problem a challenge is that these aids, and other aids such as the use of a neighboring student's paper, are not allowed. The Resources specify that students are to do their own work, without the use of crib notes or a dictionary.

For the mathematically oriented reader, another excellent example is provided by the problem situation of trisecting an arbitrary angle. In the figure below, angle ABC is an arbitrary angle (i.e., it is of unspecified size). The goal is to do a geometric construction that divides angle ABC into three equal angles.



Given angle ABC

Sometimes the Resources specify that one is only allowed to use a straight edge, compass, and pencil. In that case it can be proven mathematically that the problem cannot be solved. In other cases one is allowed to use a protractor in addition to the other implements. Then the problem is easily solved by measuring the angle, dividing the number of degrees by three, and constructing new angles of the resulting number of degrees. Note that in the latter case the compass is not used, even though it is available. Solving real world problems is sometimes difficult because many resources are available, and often it is not clear which ones to use to solve a particular problem.

For a third example, consider this problem: Teachers in a particular school seem to be using substantial amounts of pirated software. You can investigate the problem situation to clarify the given situation (that pirated software is being used by teachers). You can set a goal, such as reducing the use of pirated software by two-thirds in the first year and decreasing it still more the second year. As a responsible and ethical educational leader, you may have considerable ownership of the problem situation. But what are the Resources? What types of things can you do that might help achieve the goals?

Brainstorming, individually or in groups, is often used to develop a list of Resources or potential activities you might carry out to solve a problem. For example, teacher software piracy might be reduced by an informational program, providing money to buy enough software, threats of dismissal, and so forth. Further exploration would be needed to determine if these options were actually available to the problem solver.

Steps in Problem Solving

In this section we list a sequence of steps that may be followed in attempting to resolve a problem situation. Often we carry out some of the steps quite automatically with little conscious thought. But it can be quite helpful to consciously think about each step in problem situations that seem to be giving us trouble. (Here we are assuming the Ownership condition is satisfied; that is, you are interested in resolving the problem situation.)

1. Work with the problem situation until you have converted it into a well-defined problem; that is, until you have identified and understood the Givens, Goal, and Resources. This first step is a creative, higher order thinking process, which often involve considerable knowledge as well as a good sense of values. Two different people, when faced by the same problem situation, may come up with quite different well-defined problems.

2. Select and/or develop a procedure that is designed to solve the problem you have defined. This is an information retrieval and/or creative thinking step. Usually it involves both; computers may be useful in retrieving needed information. (We will discuss the idea of *procedure* more in the next section of this Chapter.)

3. Execute or cause to be executed the steps of the procedure. Sometimes this will be a mechanical, nonthinking activity, where speed and accuracy are desired and computers may be quite useful. (The executions of many mathematical procedures falls into this category.) At other times the execution of a procedure will require the best of truly human skills. (The work of a good psychotherapist falls into this category.)

4. Examine the results produced in Step 3, to determine if the problem you defined in Step 1 has been solved. If it has been solved, go on to Step 5. Otherwise, do one of the following:

   a. Return to Step 3 and recheck your work. People and machines sometimes make mistakes.

   b. Return to Step 2 and determine another approach to solving the problem you have defined.

   c. Return to Step 1 and determine another problem to be solved.

   d. Give up, or seek help from others. The problem might not be solvable, or it might be beyond your abilities, or it might be beyond the efforts you are willing to make at this time.

5. Examine the results produced in Step 3 to determine if the original problem situation has been satisfactorily resolved. If it has, you are done. If it hasn't, do one of the following:

   a. Go to Step 1 and determine another problem to be solved.

   b. Give up, or seek help from others.

Problem-solving research suggests that students benefit from learning and practicing the above five-step approach to problem solving. It is applicable over a wide range of disciplines and problem-solving situations. Notice that success is not guaranteed, but that persistence increases the likelihood of success. Note also the personal nature of the five-step approach. Problem solving is a personal thing, and personal values are often central to a problem situation.

What is an Effective Procedure?

When you are able to solve a particular type of problem routinely or automatically, you have developed one or more procedures (algorithms, detailed sets of directions, recipes) for this type of problem. Computer scientists are deeply concerned with developing procedures that tell a computer how to solve a certain category of problem. We will use the phrase *effective procedure* in

discussing the idea of a procedure that can be carried out in an automatic, nonthinking, computer like mode.

More formally, an effective procedure is a detailed, step-by-step set of instructions having the two characteristics:

1. It is designed to solve a specific problem or category of problems.

2. It can be mechanically interpreted and carried out by a specified agent. Here the term "mechanically interpreted" means in a machine-like, nonthinking manner. Computer scientists are interested in situations where the agent is a computer or a computerized machine such as a robot.

Computers are important because they can rapidly, accurately, and inexpensively execute many different procedures. The number of such procedures continues to grow very rapidly through the work of researchers in all disciplines, computer scientists, and computer programmers. Thus, an understanding of the concept of effective procedure is generally considered to be an important part of computer literacy, and it certainly lies at the heart of having a general understanding of roles of computers in problem solving.

Roles of Computers

In this section we briefly examine each of the five steps one might follow in resolving a problem situation. Our intent is to point out roles of computers in each step and to briefly discuss possible curricular implications.

The First step is to understand the problem situation and work toward having a well-defined problem. This is a thinking step, drawing on one's general knowledge as well as specific information about the problem situation. That is, both a broad general education and in-depth knowledge about the specific situation are useful. Many educational leaders argue that a broad liberal arts education is useful in understanding and critically examining the wide range of problem situations one encounters in our society. Values education plays an important role here, since the process of developing a well-defined problem from a problem situation often depends heavily on personal values and views.

Computer Assisted Learning (CAL) is of growing importance in acquiring education for understanding problem situations. Research evidence strongly supports the contention that students generally learn faster in a CAL environment than they do in a conventional instructional environment. There is strong research evidence that CAL is a cost-effective aid to students. The evidence is strongest in the acquisition of factual knowledge, or at the lower-order level of Bloom's taxonomy. Computerized drill and practice works!

The Second step is to select and/or develop a solution procedure for the well-defined problem you have produced in the first step. You might select and retrieve a solution procedure from your head.

As an example, the problem might be to determine the number of cubic yards of concrete needed for a patio that is to be 12 feet wide, 15 feet long, and 4 inches thick. A procedure to solve this problem involves conversion of units, multiplication, and division.

S1: Convert 4 inches to feet (by dividing it by 12).

S2: Multiply the three dimensions (each given in feet) to find the number of cubic feet in the patio.

S3: Divide the answer produced in Step 2 by 27, to convert it to cubic yards.

It is important to realize that there can be many different procedures for solving a problem. Here is another approach to solve the patio problem:

S1: Convert all measurements to yards. This involves dividing the measurements given in feet by 3, and dividing the measurements given in inches by 36.

S2: Multiply the three dimensions (each given in yards) to get the number of cubic yards of concrete needed for the patio.

The mental selection and/or development of a solution procedure is a thinking process. One can gain skill in this thinking process through practice. Computers can be used to create practice situations. Many simulations or simulation/games are designed to provide practice in this problem-solving step.

An alternative to retrieving a procedure from your head is to retrieve it from a library, which may contain books, periodicals, films, and so forth. Many libraries have replaced their card catalogs by computerized card catalogs. Moreover, much of the information needed is now stored in computers. One of the defining characteristics of the Information Era we are now in is the growing availability of information and the growing technology to aid in information retrieval. It is clear that computers are very important in retrieving procedures for solving problems. This strongly suggests that all students should learn to make use of these aids to information retrieval.

The Third general step in resolving a problem situation is to execute or cause to be executed the procedure from the second step. As we have indicated, some procedures require a "human touch." Others can be executed mechanically, in a nonthinking fashion. A large and rapidly growing number of procedures can be executed by computers or computerized machinery.

If a computer can execute or help execute a procedure, what aspects of this procedure do we want people to learn to do mentally, assisted by pencil and paper, assisted by noncomputerized machinery, or assisted by computerized machinery? This is a very difficult question, and it will challenge our educational system for many years to come. The answer that seems likely to be widely accepted is that we want students to have a reasonable understanding of the problem being solved and the capabilities/limitations of the computerized procedure. We want students to remain in control, but we want them to work with computers rather than in competition with computers.

The Fourth and Fifth steps in resolving a problem situation require examining the results of your work to determine if you have succeeded. These steps require critical thinking, drawing on your understanding of the initial problem situation and the steps followed in resolving the situation. These are higher-order mental activities.

The research literature on problem solving strongly supports the idea that people get better at problem solving if they study the processes of problem solving, learn to use aids to problem solving, and practice problem solving. This suggests that students should learn to use computers as an aid to problem solving in disciplines for which computers are an useful aid. They should practice solving problems, making use of computers when their use is appropriate to the problems being solved.

Software

In a broad sense, all computer software can be considered as problem-solving software. But when we think of preparing teachers and/or students to deal with computers in schools, problem-solving software tends to fall into three main categories:

1. Programming languages such as assembler, BASIC, C, COBOL, Logo, Pascal and Pilot.

2. Application packages, such as a graphics, spreadsheet, or database package. Some application packages are useful across many disciplines, so we call them "generic." A word processor is a generic application package. Other application packages are useful in quite limited contexts; an example is provided by software for writing music.

3. Simulations/games specifically designed to help students learn general or quite specific problem-solving techniques. For example *The Factory* published by Sunburst Communications is designed to teach planning ahead and to improve spacial visualization skills.

There are hundreds of programming languages. In all cases the intent is to make it possible for a human to communicate with a computer. Usually a programming language is designed to meet the needs of a particular category of computer programmers. For example, BASIC was originally designed for college students, COBOL was designed for business data processing programmers, and Pilot was designed for writing Computer Assisted Instruction materials.

In all cases one uses a programming language to specify procedures to solve certain categories of problems. This is a very important concept. The writing of a computer program to solve a problem requires both a knowledge of a specific programming language and skill in developing procedures to solve problems. The latter is called *procedural thinking* and is generally considered to be an important component of computer literacy. Skill in procedural thinking is independent of any particular programming language. Indeed, one can develop a high level of procedural thinking skill independently of whether computers are available or whether computer programming is used to represent the procedures.

Computer-in-education leaders have not reached consensus as to which students should receive instruction in computer programming, at what grade levels, or using which particular programming language(s). For example, many school systems have decided to provide instruction in Logo to all of their elementary school students. Other districts have decided to include some BASIC in a junior high or middle school computer literacy course required of all students. Still other school districts have decided that computer programming is best left as an elective course, perhaps mainly available to secondary school students who have had a reasonably strong mathematics preparation.

Applications software may be generic (useful over a wide range of disciplines or problem areas) or it may be quite specific to the problems in a particular discipline. A computer graphics package is useful over a wide range of disciplines, while music composition software has much more limited applicability. A trend has begun to emerge, and it seems likely to continue. Many school districts have decided that all students should learn to use a variety of generic applications software. The use of such software will be integrated into the total curriculum. Initial instruction may be in a variety of courses at a variety of grade levels, or it may be concentrated into a single computer literacy course.

At the same time there is growing realization that each discipline has its own applications software. Thus, as students study a discipline at a higher and higher level, they need to receive specific instruction in use of the applications software of the discipline. Thus, two types of computer literacy are emerging. A computer literate student uses generic computer applications software as appropriate in working with problems in every academic area. As a student progresses to higher levels or greater depths in any particular discipline, the student becomes more and more computer literate within that specific discipline. For example, a student who takes college preparation courses in chemistry and physics should be learning quite a bit about applications software specific to the fields of chemistry and physics. Microcomputer based laboratory (MBL) software falls into this category.

There are many general purpose problem-solving techniques. For example:

1. Plan ahead, anticipating the consequences of proposed actions.

2. A large, complex problem can often be solved by breaking it into several smaller, less complex problems.

3. It is often helpful to draw a picture or map, or in some other manner graphically represent the problem under consideration.

4. It is often helpful to write down the steps you take in an attempt to solve a problem.

Many different simulation/games software packages have been developed to give students practice in particular problem-solving techniques. Research into the value of such software is sparse. The main difficulty seems to be the issue of transfer of learning. For a particular simulation/game, it is evident that students get better as they practice using the software. That is, they get better at applying particular techniques in the context of the simulation/game under consideration. But there appears to be relatively little transfer of the techniques to other problem-solving situations. It seems likely that the teacher plays a very important role in helping to increase such transfer of learning. A teacher can provide a wide variety of examples, suitable to the academic level and interests of a particular student, where the techniques are applicable. A teacher can help encourage students to apply the problem-solving techniques they have studied to the variety of problems they encounter throughout the school day.

Transfer of learning is a key issue in all of education. Every teacher in every subject area should be aware of the difficulties of transfer and that transfer can be increased by proper teaching techniques. The facilitator of a computer integrated instruction inservice is working to provide teachers with a powerful aid to problem solving. But we know it is not enough to merely teach the teacher how to use the tool. The teacher needs to learn to use the tool in a classroom setting. Moreover, the teacher needs to learn how to help students learn to use the tool as a general purpose aid to problem solving across all disciplines and also outside of school settings. This is a formidable task.

Chapter 1.4
Change Processes in Education: What Does the Literature Tell Us?

The computer inservice facilitator is in a unique position to be a change agent in education. But relatively few inservice facilitators have thought carefully about educational change. This chapter summarizes some of the key ideas about educational change.

Change is difficult. It is difficult to imagine, difficult to plan for, difficult to implement, difficult to manage, and difficult to measure. Fullan (1982) states that, in the educational context, "change involves 'change in practice'" (p. 30) and he demonstrates several difficulties. For one, change is multidimensional; new materials, new teaching approaches, and alteration of beliefs must be considered.

Inservice training is a major tool in the implementation of educational change. In reporting a research-based model for such training, (Gall & Renchler 1985; the Gall & Renchler book is included in its entirety as Chapter 2.1 of this book.), the authors state, "No one yet pretends to have discovered all the elements that make staff development programs completely successful" (p. 1). One reason for this is the difficulty in designing studies that can "tease out" the effective practices from the background noise of incidental and uncontrolled effects. The most reliable measure of effectiveness—change in student behavior—is several steps removed from the major actions of most staff development programs. Joyce and Showers (1983) describe a model involving classroom-level coaching that promises to take the training all the way to the level of observation of actual classroom practice, but such designs are rarely implemented due to limitations of time and funding.

Because change takes time and is best viewed as an ongoing process, the internal state of the learners—in this case, teachers themselves—is an important consideration. Hall (1982) showed that it is desirable to match inservice to current levels of concern of the individual participants. Furthermore, continued tracking of the evolution of their level of concern can function as a diagnostic tool for modifying the content of training "on the fly," should modifications be necessary.

The literature on inservice designs that are specific to computer education is sparse. Gabel (1984) reviews the work of Isaacson (1980), Winner (1982), and Ferres (1983), and finds, that their essentially descriptive studies do not speak to the issue of effectiveness, but instead concentrate on the mechanics of developing and presenting special purpose inservice training. Gabel's own work concluded that the model suggested by Gall and Renchler (1985) was a valid and useful framework for organizing computer education inservice.

In this section, the categories for the dimensions of inservice follow those outlined by Gall and Renchler (1985) and are divided into five categories: content and organization, delivery system, organizational context, governance, and evaluation.

Inservice Dimensions

Content and Organization. The realm of the planning, development, delivery, and follow-up of actual training sessions is below the level of more global concerns such as the environment in which inservice is provided, the goals and standards of the institution whose teachers are being educated, or the measures by which the inservice program is to be evaluated. Of course, these global issues have great impact on the training to be delivered. For example, the environment may determine the resources, timing, extent and depth of the program. The goals and standards of the

institution (e.g., a school district) should strongly influence (if not actually determine) the content of the program. The measures of evaluation may direct the attention of the trainers to emphasize more closely monitored elements of the program at the expense of other elements less emphasized by the evaluation instruments.

Nevertheless, the actual conduct of an inservice may be separated from these other concerns, and a large body of literature (accompanied by a much smaller body of research) is available for inspection. The predominant feature of the literature is that it is generally based upon common practice, rather than upon actual research. In fact, the *management* and *evaluation* of inservice training is more thoroughly researched than the *conduct* of inservice.

Gall and Renchler (1985) identified the dimensions of methods of delivering an inservice:

1. *Readiness activities*. What actions are taken prior to the conduct of training to raise teacher awareness of the importance of the inservice program? How are school leaders prepared for their roles in the training? What participant information is gathered before the program begins?

2. *Instructional process*. What training methods will be used to help teachers acquire the target knowledge and skills?

3. *Maintenance and monitoring*. What provisions are made to observe and measure the actual level of application of the content of the training to classroom practice?

4. *Training site*. Is the training best carried out at the school site, or is another location more appropriate?

5. *Trainers*. What trainer characteristics may impact the effectiveness of the training program?

6. *Scheduling*. What duration, spacing, and timing should the training program have?

Competently designed inservice training programs will address each of these dimensions. The usual practice of trainers is to give great attention to the instructional process, scheduling and their own preparation.

An additional question to be addressed might consider any practical distinctions that exist among different types of learners. Are adults in general (and teachers in particular) sufficiently different from other learners that exceptions or refinements must be made to the well-researched principles of learning? (See Gagné, 1977.) Although the most general of these learning principles remain intact, researchers such as Knowles (1978) have determined that adult learners are sufficiently different from children as to merit distinct consideration. Among the important features of adult learners cited in Knowles' work are that:

1. Adults learn by doing; they want to be involved. Mere demonstration is usually insufficient. Practice and even coaching are highly desirable.

2. Problems and examples must be realistic and relevant to them *as adults*.

3. Adults relate their learning very strongly to what they already know. They tend to have a lower tolerance for ambiguity than children, so explicit attachment of new knowledge to their existing base is a paramount necessity.

4. Adults tend to prefer informal learning environments, which are less likely to produce tension and anxiety.

5. Changes in pace and instructional method tend to keep the interest of the adult learner high.

6. Unless the conditions of training absolutely require it, a grading system should be avoided. Checklists of criteria met in the course of training, for example, are less intimidating than the assignment of grades.

7. The instructor should frame his or her role as that of a facilitator of learning rather than as a font of knowledge or expertise. This guarantees that participants will find the trainer approachable, an absolute precondition of communication between adult learner and teacher.

It is obvious that these adult learner characteristics are of great concern to the teaching of adults and they should govern several aspects of the preparation, delivery, and follow-up. The impact of these elements of training is discussed below in summary with lessons learned from other sources.

In a study of the impact of inservice on basic skills instruction, Gall et al. (1982) identified a number of deficiencies in the ordinary conduct of inservice. Researchers judged that programs exhibiting such deficiencies will have little impact on teacher practice or student performance.

1. Programs tended to be focused on the professional goals of individual teachers rather than on the improvement of the school instructional program. Teachers' goals and school needs are not always in consonance.

2. One-shot training or short sessions failed to show impact on the school's instructional program.

3. Although the inservice programs were sponsored and financed by districts or schools, the general plan and learning activities of the training were based on goals and objectives that had little or no demonstrable connection to those of the school or district.

4. Programs were very rarely assessed on the basis of actual improvement of student performance.

5. Most inservice programs lacked several of the following desirable features: readiness activities, a meeting, follow-up activities, and in-classroom observations to identify changes in teacher behavior that might be attributed to the inservice training.

Much of the work of Joyce and Showers (1983) centers on governance issues, but they also have critical points to make concerning the conduct of inservice:

1. Training may be considered to be composed of levels of involvement: lecture, demonstration, practice in the training environment, practice in the target environment, and coaching in the target environment.

2. Generally, lecture and demonstration have little impact in terms of changing teacher behavior.

3. Practice (following lecture and demonstration) contributes greatly to change in teacher behavior.

4. Coaching (following lecture, demonstration, and practice) not only contributes further to change, but also creates opportunities for dissemination of an innovation or desired practice throughout the unit (e.g., department, school, or school district) in which change is desired. One of the most promising of these opportunities is peer coaching.

Echoing elements of both Knowles (1978) and Joyce and Showers (1983) are some of the findings of the Florida State Department of Education (1974):

1. Inservice programs that place the teacher in an active role are more likely to accomplish their objectives than those which place the teacher in a receptive role.

2. Programs that emphasize demonstration, supervised trials and feedback are more successful than those that simply present new ideas or materials to teachers without opportunities for practice.

3. Programs in which teachers share and provide mutual assistance to each another are more likely to succeed than those that fail to encourage interaction during and after training.

4. Self-initiated and self-directed training activities (although seldom used in inservice education programs) are associated with successful accomplishment of program goals.

The literature offers many similar indicators of success or effectiveness in inservice conduct. They are briefly summarized as follows:

1. The content of inservice education programs should be directly and immediately linked to the goals of the agency sponsoring the training.

2. The characteristics of teachers as adult learners should be taken into account when inservice education activities are designed. In particular, the activities should be relevant to them as adults, new knowledge should be explicitly connected to previous knowledge, an air of informality should predominate, grading systems should be avoided, and the trainer should act as a facilitator.

3. Designs that feature multisession contact and development of an ongoing relationship between trainer and teacher is preferred over one-shot designs.

4. If possible, the training should include not only presentation of information and demonstration of new methods and skills, but also supervised practice and coaching.

Organizational Context. When referring to the organizational context in which inservice education occurs, Gall and Renchler (1985) echo the "modal systems" of Joyce and Showers (1983). While Gall and Renchler recognize the five modes identified by Joyce and his colleagues, they prefer to think of these modes as representing different functions of inservice education and go on to identify four such purposes: (a) inservice for personal professional development; (b) inservice for credentialling; (c) inservice for the purpose of induction into the profession; and (d) inservice for school improvement.

"Inservice for school improvement" speaks directly to the school as an organization. Operationally, one can define the organizational context as those organizational elements of the school that directly influence the success of inservice education. But organizational context also implies a series of interrelated components that work in relative harmony. To divorce any one component from the whole distorts our perception of and reaction to that element. Just as our perception of our environment is continuous, so the school must be viewed holistically as a continuous, dynamic collection of interlacing and interactive parts.

A meta-analysis done by Lawrence and Harrison (1980) concludes that the most effective inservice programs address the school as a unit. Their research supports the contention that inservice is most effective when the emphasis is on global goals rather than personal development.

These findings are consistent with the observation of noted anthropologist Edward T. Hall (1981) about the essential nature of the context of expression and action. He states that context

determines everything about the nature of the communication and predicates further behavior. A focus on school improvement places the "situational dialect" of the teacher professional life of the teacher within the larger frame of the school as a complete unit. This broad focus of shared goals gives a context of discussion in harmony with the larger organizational context. A somewhat different but complementary observation is made by Pitken (1972) when she examines the question of social membership. She notes that with respect to learned or cultural norms, the wholeness and uniformity of our society is determined by the acquisition of like patterns by people exposed to them. These views lead again to the conclusion that the more consonant the goals are with the school, the more consistent will be the patterns of compatibility between the behavior elicited and those expressed by the administration and support staff. In essence, the new behaviors or activities must mirror the intentionality of the school as a unit.

If we place the goals of the inservice within the larger framework of the school environment and provide a collegial support structure, chances of institutionalizing any changes are improved. In a fundamental sense, the organizational context provides the ecological gestalt of action and interaction. Compatibility between the objectives of the inservice and those of the school is essential if changes are to be made a part of the taken-for-granted background of the teacher, administrators, and support staff in their daily activities.

Holly (cited in Gall & Renchler, 1985) surveyed 110 teachers and found a general preference for activities that allowed them to work with other teachers. Ngaiyaye (cited in Gall & Renchler, 1985) found that teachers preferred to work with teachers who had similar educational duties. Domain-specific knowledge as defined by Doyle (1983) consists of an explicit semantic network of relevant information and identified methods or strategies for applying that information. Although Doyle was addressing academic content, it seems clear that the same theme can be applied effectively in inservice education. Thus, not only does educational research support the need for teachers to work with teachers, but it supports a more specific domain of discourse in which they share their goals and concerns with teachers in their own or similar subject areas. In a collegial environment made up of their peers, teachers can relate common concerns and share methods or strategies central to their needs as educators (U.S. Department of Education, 1986). Furthermore, teachers with similar instructional assignments can share materials, tools, and new methods of instruction.

Unfortunately, there appears to be no research examining the relative effectiveness of variations in teacher inservice groupings as defined by Gall and Renchler (1985). Wade (1985), however, does indicate in her meta-analysis that participation by both secondary and primary school teachers is more effective than either group working alone.

In an organizational context, the school principal as an instructional leader plays a major influential role. Research by Louchs and Pratt (cited in Gall & Renchler 1985) indicates that the role taken by the principal in the implementation efforts of a program is essential to the success of the project. Leithwood and Montgomery (cited in Gall & Renchler 1985) have shown that an effective principal will participate in at least part of the inservice workshops attended by the staff. Finally, the Rand study (cited in Gall & Renchler 1985) suggests that without the approval of the principal, teachers generally will not implement a new curriculum or process.

As noted above, the school is a dynamic but loosely coupled organization. This loose coupling requires a mediating force that lends a coherence to its structure. Thus, the principal seems to act as a lens to keep school goals clearly in focus and as a guide to keep teachers on track with district objectives (U.S. Department of Education, 1986).

Governance. The issue of governance frames the larger context of school as a functioning unit. *Operationally we can define governance as that organizational process of decision making that determines school policy and directs school resources.* The governance of inservice education specifically addresses concerns about the way an inservice will be designed and offered to the district staff. The study by Mertens (1982) clearly shows that the view of the teacher as a professional must pervade the district; when teachers are viewed as professionals, inservice projects are more successful than when teachers are viewed merely as functionaries. All projects and or policy decisions need to be approached in this light.

There appears to be no research on the most effective infrastructure for carrying out the process of governance at the district level. However, there is ample research to indicate that this process must take into account teacher concerns and expectations. Many researchers indicate that the teacher must be given the opportunity to be part of the planning. If teachers are not consulted, the results can be disastrous. Wolcott (1977) documented a carefully planned effort for educational change in a school district in Oregon. This mammoth seven-year plan involving several hundred thousand dollars, vast district resources, and uncounted hundreds of hours for both planners and teachers failed. Its primary failure was that it did not take into account the needs of the educator. It was conceived as a "top-down" approach and implemented as such.

Wolcott reaffirms the importance of teacher participation in the planning process. What is not clear is how much control teachers should have over the inservice content. On one side is the work of Schurr (cited in Gall & Renchler, 1985), where it is shown that teachers desire input into the planning process; on the other side is the work of Wade (1985) that indicates inservice sessions were gauged as "less successful" if participants were regarded as the major contributors to the process. Indeed, her meta-analysis shows that inservice sessions are more effective if the leader assumes the role of "giver of information" and teachers as "receivers of information." Clearly, a balance seems necessary. It is important to ascertain the needs of teachers so that inservice sessions can be directed specifically to their needs. On the other hand, the integrity of the inservice content must be maintained, with policy and planning decisions attempting to strike a balance between teacher input and district needs.

Another issue of governance is the recruitment of participants. Motivation to attend inservices can be subtly but definitely enhanced if the research outlined in this section is taken into account. A feeling of personal connection with the concerns of the inservice is also important. Moursund (1988) suggests that ownership in a problem-solving process is critical. Inservice by definition is a form of problem solving. If participants can feel a sense of ownership of the content of the inservice, they will want to attend and take seriously the purposes of the project.

Wade (1985) confirms the need to have a sense of ownership, pointing out that inservice is more successful when the teachers are given special recognition for their involvement. But she further reports that projects are more successful if teachers are either designated to attend or selected on a competitive basis. Clearly, the research confirms the need of teachers to be a willing part of the process, but it also indicates that directing teachers to attend is not predictive of failure. Obviously, this is a complex issue: *How* teachers are directed to attend is important; the content and relevance of the inservice is important; the organizational context is important; and the way the issue of governance has been handled in the school is historically important.

Other incentives for attending inservices described by Betz (cited in Gall & Renchler, 1985) are release time, expenses, and college credit. Administrators, however, can take heart in Wade's (1985) finding that almost any inservice can make a difference. She reports that inservice of any kind, on the average, resulted in half a standard deviation greater positive change than control groups. This is a clear indication that inservice education can influence the quality of the educative process.

In summary, effective inservice must take into account the school organizational context and its governance policies. It appears that the more the inservice speaks to the unifying goals of the school, the more effective will be the results.

Evaluation. As stated in Gall and Renchler (1985): "The evaluation of inservice programs is not a well-developed field," and "... systematic evaluation of inservice programs is the exception rather than the rule (p. 30)." In an effort to bring some order to the field, Gall and his colleagues (1976) attempted to define the different levels at which inservice training might have effects. They defined four levels:

Level I: *Implementation of the inservice program.* (Measures of the quality of the training itself.)

Level II: *Teacher improvement.* (Measures of actual change in teacher behavior in the classroom.)

Level III: *Change in student performance.* (Measures of the degree to which improvements in teacher performance lead to improvements in student achievement.)

Level IV: *Changes in the environment.* (Measures of changes in the school that may be indirect [or even unintended] results of the inservice program.)

The further away we get from measuring the direct delivery of training, the less certain we can be that changes in Levels II, III, and IV are actually attributable to the training program. Other factors, unpredicted and unmeasured, may have greater impact than training.

At Level I, the elements mentioned previously in the Content and Delivery System section (readiness activities, instructional process, maintenance and monitoring, training site, trainers, and scheduling) should be measured directly. In addition, some quantification of the degree of relevance of the program to teachers' perceived and actual needs should be attempted.

At Level II, the best measures are those of increased teacher competence. If the program is of novel content (as a computer inservice might well be), conventional measurements might have to be supplemented with new ones that reflect the content of the training. Observational measures of actual classroom practice are the preferred instruments.

At Level III, measures of student achievement are appropriate. Because this level is rather far removed from the training, it may be difficult to attribute changes in student behavior directly to actual inservice practices.

At Level IV, we hesitate to suggest methods of measurement. Although instruments can be created to measure school climate and levels of intercommunication among the staff (Joyce, Hersch, & McKibbin, 1983), it is perilous to presume explicit connections between an inservice program and a change in the school environment.

Conclusion

To narrow the scope of the literature on effective inservice, this review concentrates on literature dealing with the actual conduct of inservice.

The five dimensions of inservice (i.e., content, delivery system, organizational content, governance, and evaluation [Gall & Renchler, 1985]) were used to examine the literature. The predominant feature of the literature is its bases in common practice, rather than on actual research. Literature specifically related to implementing changes in educational computing is extremely limited. The literature that exists concentrates on the delivery system aspect of Gall's classification.

Currently, staff development is the major tool for implementing educational change. Reviewing the literature confirmed our intuitive belief that effective inservice is difficult to attain for the following reasons:

1. Change is multidimensional. (We are dealing with change in a school system, and a school system is a very complex entity.)

2. Change is a slow process. (It is the nature of a stable and functioning system to resist change. School systems seem to be exceptionally resistant to change, and change only slowly.)

3. Effective inservice is resource intensive. (In many settings the resources available for inservice education may not be adequate to produce a significant change.)

4. Learning styles of adults are complex. (A typical inservice will involve adults with widely varying interests, characteristics, and backgrounds.)

5. Global characteristics of school systems, many of which are outside the influence of the inservice provider, influence change.

6. Participation of teachers in the process of setting goals for inservice may enhance the learning of the participants, but it is difficult to properly achieve this participation in goal setting.

7. Mechanisms for evaluation of inservice programs are ill-defined and infrequently attempted.

Chapter 1.5
Scenarios from an Information Age School

The CII inservice facilitator is a key educational change agent. The facilitator has knowledge of education and of the computer technology that may be the basis for a major change in our educational system. Moreover, the CII inservice facilitator has access to teachers and has the opportunity to help move them toward technology-based changes in the content they teach.

For these reasons, it is essential that the CII inservice facilitator have a good understanding of what constitutes a good education for life in an Information Age society and for the continued change that students will face throughout their lives. This chapter was originally written specifically to depict possible changes in mathematics education. But, in a larger sense it serves as a metaphor for technology-based changes in our educational system. If you are giving math-oriented inservices, the material in this chapter will be of specific and immediate interest to you. If your interests do not include mathematics, then read this chapter with the idea that it is a model of educational change. Create your own model to fit the areas in which you are doing inservice facilitation.

You will notice that it is expected that the reader understands some of the purposes and underlying concepts of mathematics education. If you are doing inservice designed to impact people who teach mathematics, it is important that you understand mathematics education. It is not enough to just understand the computer tools that you are teaching math educators to use. You need to facilitate them learning to make appropriate use of these tools as they change the mathematics curriculum. To do this, you need to have a good understanding of mathematics education.

Information Age Mathematics Education

It is not obvious what constitutes an appropriate education for life in an Information Age society. This chapter gives three scenarios from mathematics education settings in hypothetical Information Age classrooms of the near future. The chapter begins with a discussion of the goals of mathematics education. The reader will want to examine the scenarios to see how well they reflect the goals. Also, look for how well the scenarios reflect your ideas on what might constitute an appropriate education for life in an Information Age society.

Much of the inservice education that is needed to support computer integrated instruction needs to be specific to the discipline interests of the participants. It is quite difficult for a person who knows little about mathematics or the teaching of mathematics to present an effective computer inservice for mathematics teachers. If you are thinking about designing and implementing computer inservices for mathematics teachers, then this chapter may prove to be a good test of how well you are prepared. The contents of this chapter might well be assigned reading for secondary school math teachers participating in a computer inservice.

Brief History of this Chapter

The material in this chapter is extracted from a paper that has evolved over a number of years and has been used for a variety of purposes. A brief history of the longer paper follows.

In the fall of 1985 the National Research Council created a Mathematical Sciences Education Board (MSEB). MSEB set as its initial task to make recommendations on precollege mathematics education for 10-15 years in the future. In June 1986 I was asked to submit a position paper discussing possible roles of computers in such a mathematics education system, and I did so in October 1986. Nearly a year later I made use of a modified version of that position paper in a presentation done in a fall 1987 computer education conference in Alberta, Canada. Still later I modified the paper again, to reflect input I received in Alberta and from others who had read the paper. Then the paper was used as a resource and discussion-topic paper in the Computers and Mathematics course taught in the University of Oregon summer session 1987.

MSEB held a working session of 20 mathematics educators during August 10-14, 1987 at the Xerox Training Center in Leesburg, Virginia. The five person working group I was in focused on possible roles of technology in mathematics education in the year 2000 and beyond. Other members of my working group were Richard Anderson (Louisiana), Gail Burrill (Wisconsin), Margaret Kasten (Ohio), and Robert Reys (Missouri). I used my modified position paper as the starting point for the writing I did during that session. After a number of major additions and revisions, it doubled in length and began to reflect quite a bit of the thinking of our group, as well as some of the ideas of the MSEB. Since that working session I have revised and expanded the paper quite a bit more.

The version of the paper presented here has been revised to fit with the general theme of effective inservice.

Introduction

The purpose of this chapter is to provide a framework for planning major curriculum content and pedagogy changes designed to improve our mathematics education system. Most educational leaders believe that our precollege mathematics education system in the United States is not as good as it should and could be. They cite as evidence test scores within this country, international comparisons, and a variety of national reports of study groups.

It is worth noting that during the past few years there have been a number of national commissions and other groups that have commented on the total educational system in the United States. Their remarks tend to parallel the remarks found in reports directed specifically at our mathematics education system. The general opinion represented in such reports is that substantial reform is necessary if our educational system is going to adequately meet the needs of our country.

Here are five major factors that suggest change is necessary and improvements are possible in our mathematics education system:

1. The nature of the intended audience of our mathematics education system has changed quite a bit in the past couple of decades. For example, kids in high school now have spent about as much time watching TV as time in school. They have spent their entire lives in the Information Age, while our school system was designed to fit the needs of an Industrial Age society. (According to John Naisbitt, the Information Age officially began in the US in 1956.) This analysis suggests that mathematics education might be improved by moving it more towards the needs of people living in an Information Age society.

   One key component of the Information Age is rapidly increasing access to more and more information. A common estimate is that the total accumulated knowledge in mathematics is doubling every ten years. This suggests that information retrieval skills are of increasing

value and that math-oriented information retrieval be given increased emphasis in the curriculum.

2. Over the past couple of decades there has been substantial progress in our understanding of teaching theory, learning theory, and cognitive science. Our educational system tends to be slow in translating such theory and research results into practice. While progress is occurring, much remains to be done. Research is continuing at a rapid pace.

   Research into cooperative learning and cooperative problem solving strongly supports their potential in education. This suggests that cooperative learning and cooperative problem solving should be given increased emphasis in the mathematics curriculum.

3. Calculators and computers can be used to help students learn mathematics topics. (One of the topics might be to learn to use a calculator or computer to help solve math problems.) The research literature on computer assisted learning (CAL) is extensive and quite supportive of increased use of CAL. While much of the research in the use of CAL in mathematics focuses on basic skills, the body of literature on uses to improve higher-order skills is growing. There is quite a bit of software designed to enhance higher-order skills.

   CAL can make available instruction in individual topics or entire courses that might not otherwise be available to students. It can incorporate pedagogy (for example, sophisticated simulations and motion graphics) that is not readily duplicated without the use of a computer.

4. Computers can be a substantial aid to classroom management and to testing, especially as one works to meet the diverse needs of individual students. Computers can help increase the amount of individualization of instruction in our math classrooms.

   Computers also can be an aid to teachers in whole-class presentations and activities. Most math teachers already know how to use an overhead projector. There are now relatively inexpensive devices (about $1,000) that allow the output from a computer to be projected using an overhead projector. Many math teachers will eventually find such a system to be quite valuable in their teaching. The cost of these devices will likely decrease substantially in the next few years.

   Substantial progress has occurred in developing computer based classroom management and record keeping systems. This is called computer managed instruction (CMI). Computer assisted learning systems often contain a build-in CMI system. CMI systems also exist that can help track students in their total educational program.

   Many teachers have learned to make effective use of an overhead projector, film strips, etc. A computer, or a computer system with a videodisc, is "merely" another instructional medium. But it is a powerful medium that can be especially useful in supplementing traditional standup lecture demonstrations in a math class.

   Computer based, adaptive tests, are gradually being developed by the Educational Testing Service and other groups. Such tests adjust the questions being presented on the basis of student responses, thus more quickly arriving at a solid estimate of student performance in a specified area.

5. Calculators, computers, and other related technology have become more and more available as aids to productivity and problem solving in our society. Our current mathematics curriculum largely ignores possible impacts of computer related technology on content. Perhaps the classical examples are the use of quite inexpensive calculators to do arithmetic

calculations and the use of computers (or, more sophisticated calculators) to graph data and functions. Widespread implementation of even just these two types of aids to problem solving would have a significant impact on the mathematics curriculum.

This paper focuses largely on the last of the five factors listed above, the computer-as-tool.. This is also called computer integrated instruction. However, the other four factors are also given serious consideration.

Nine Overriding Goals

This section suggests nine overriding goals that can be used when examining an existing or proposed mathematics education system. The first six are goals for students to achieve, and the educational system should be designed to provide students good help in achieving these goals. The seventh goal specifically mentions technology. *While the computer is important both in shaping mathematical content and in pedagogy, it is clearly not the central theme or purpose in mathematics education.* The eighth indicates that our mathematics education system needs to be concerned with preserving itself. The last goal is for teachers.

G1. *Reasoning*. The goal is that in a mathematical context students can argue, conjecture, validate, prove, follow proofs and logical arguments, etc.

G2. *Mental mathematics*. Within the framework of the mathematics that students have studied, they can:

a. Mentally solve "simple" problems. (What is simple will, of course, vary with the student. But, for example, most students can learn to do one digit addition and multiplication; to mentally decompose a modestly complex geometric figure into component parts (for example, note that a kite-shaped figure can be decomposed into two triangles); to mentally collect terms in an algebraic expression; to transfer simple mental counting and computational skills to real world situations such as dealing with money; to visualize graphs of simple functions, etc. Here we set as a goal that students have "number sense," as well as "Mathematics sense" at a level appropriate to the math that they have studied.

b. Mentally estimate answers to problems of a considerably greater complexity than those under (a) above. Mental estimation in arithmetic, for example, builds on having good mental computational skills. Mental graphics allows one to visualize the shape of a function or the graph of some data.

c. Have a reasonably well developed "mathematical intuition" on the correctness of proposed results. Have a sense for what they know and don't know, or what is known and not known within a framework of the mathematics they have studied. (Consider two examples. First, I ask you for President George Bush's phone number. You might respond, "I don't know, but I can probably look it up in a Washington DC phone book or ask the operator." Next I ask you for President George Washington's phone number. You probably laugh and indicate that phones did not exist when he was president, or that he has been dead for a long time.)

G3. *Valuing*. Mathematics is part of our history and culture. It is a human endeavor that is fun and exciting for many people. The goal is to have students value and appreciate mathematics and their ability to know and do mathematics at the level to which they have studied it. Students should have good self esteem, and taking math classes should not damage that self esteem.

G4. *Problem solving*. Learning theorists talk about transfer of learning, and the ideas of near transfer and far transfer. Suppose that a student uses beans and bean sticks to add 8 and 13. Then it is probably a near transfer for the student to add 8 pennies and 13 pennies. It is a further transfer for an 8 year old child to determine his/her age in 13 years, or a 13 year old child to determine his/her age in 8 years. Problem solving involves the transfer of knowledge and skills. The further the transfer and the larger the number of steps required in the process, the more difficult the task tends to be. The goal is for students to learn to solve math-oriented problems that are solvable within the mathematics they have studied.

The innate ability to transfer learning to new problem situations varies tremendously among people. But appropriate education can increase this ability. Thus, there must be a major emphasis in mathematics education to teach for transfer of problem-solving skills. (Another way of saying this is that there should be a decrease in emphasis on lower-order skills and some of the time saved should be used to increase emphasis on higher-order skills. Some of the time saved could also be given over to increased emphasis on topics such as informal geometry, probability, and statistics that are not currently given enough emphasis.)

Problem solving is a rather general goal. It subsumes the following two subgoals.

G4-A *Data analysis and representation*. The goal is for students to learn mathematics needed to deal with data. This includes such things as to extract information from data, represent data graphically or in appropriate tables, use data as an aid to solving problems, appropriately tabulate statistical data, perform simple statistical computations, interpret statistical results, etc.

G4-B *Problem representation*. Mathematics provides vocabulary and notation for the representation of a wide range of problems. *The goal is that students can use the mathematics they have studied to represent real world problems*. We call this mathematical modeling, and it should be given considerably greater emphasis in the curriculum.

G5. *Communication*. The goal is for students to be able to speak mathematics and understand spoken mathematics; to read and write mathematics; and to do math-oriented information retrieval. *Our current mathematics education system is particularly weak in helping students to learn to retrieve math-oriented information, so this area needs special attention.*

G6. *Study and learning skills*. The goal is for students to develop study skills appropriate for learning mathematics and to learn how to learn mathematics. (Research supports the value in teaching study skills.)

G7. *Technology*. The goal is for students to learn to do mathematics in the type of environment they are most apt to encounter after they leave school. This means that the mathematics education system must consider the full range of environments, from the unaided human brain to a highly computerized environment.

Our understanding of transfer of learning suggests that if we want students to function well in a particular environment, we should educate them in that environment. Thus, if we want students to learn to function well in an environment in which computers are routinely used as an aid to problem solving, we should educate them in an environment in which computers are routinely available and used as aids to problem solving.

G8. *Producing mathematics leaders*. As we work to improve our mathematics education system, we need to pay special attention to students who have particularly good mathematical ability. The goal is to foster this ability and to help these students develop a strong interest in mathematics. The future of mathematics education depends on having a continuing supply of very competent mathematicians and mathematics education leaders.

G9. *Teachers' role*. The goal is for teachers to adequately and appropriately facilitate students in G1-G8 above. Research suggests that it is helpful if teachers role model the behaviors they want their students to learn. Thus, one specific goal here is for teachers to learn to role model learning and doing mathematics in an environment that includes calculators and computers.

Scenario 1 (A Third Grade)

This is the first of three scenarios reflecting ideas on the mathematics curriculum of the year 2000. This scenario represents a third grade classroom in the year 2000. Other scenarios in this chapter give glimpses into possible futures of middle school and high school.

It is the year 2000, a little before 10:00 in the morning, and you are visiting a third grade classroom. As you enter the school building it reminds you of when you were in school. Not surprising, since you attended this same school twenty years ago. New school buildings are somewhat rare.

You have asked the teacher to tell you when the math period would be. The teacher hedged the answer, indicating that students may be doing math types of things at almost any time of the day. However, at 10:00 in the morning most of the class is typically engaged in a math type of activity.

As you walk into the classroom you notice that there are a number of computer display screens and keyboards, several with groups of 2-4 students around them. You do a rapid mental estimation that suggests that there is roughly one computer work station for every three students in the class.

You notice the teacher working with a group of students. The students are practicing mental computation. A student has posed the problem of finding the sum of 23 and 18. As you mentally try to visualize these two numbers lined up vertically in your head, you hear several students and the teacher respond with an answer of 41. Terry, one of the students in the group, explains one way to do it. "I think of a reference number that is near 23 and 18, and which is easy to work with. I use 20, since I can easily see that 20 plus 20 is 40. But 23 is 3 more than 20, and 18 is 2 less than 20. So, I need to add 1 to 40 to get the answer." The teacher says, "I did it a little different. I saw that 23 was the bigger number, so I moved some of it to the 18. That is, I changed the problem to 19 and 22, and then to 20 and 21. Then I could see that the answer was 41." Another student, Pat, says, "I remembered that 18 and 18 are 36. I then counted on from 36 as I went up from 18 to 23.

The teacher sends the students off to work together, requesting that they continue to give each other two digit addition problems to do mentally. The teacher suggests that if they have a disagreement on an answer, they may want to check it out on a calculator. You notice that there are a number of calculators readily available to students.

You ask the teacher what is going on at the computer work stations. The teacher responds that each student or group of students is likely working on something different. For example, Tom is working alone, using an "old fashioned" drill program on single digit arithmetic computation facts. You watch as Tom runs through a mixed list of addition, subtraction, multiplication, and division

exercises, completing them at the rate of about one every two seconds. You notice that when Tom makes a mistake the machine provides the correct answer and shortly later presents the same exercise again.

After about a minute or so the computer changes the presentation of the problems. It shows a rectangular pen filled with sheep in orderly rows, and asks how many sheep are in the pen. As you watch the computer presents a number of picture-based problems that are solvable by mental single digit arithmetic. After another two minutes, the computer switches to money-based drill exercises.

At the next computer work station you see three students playing a game that involves finding a lost treasure. They are looking in a castle that has many rooms on each of several floors. Frequently the clues direct them to retrace their path, move in a specified direction a certain distance, or to go to a specific room. One student is taking notes, and all three seem to be discussing the various options at particular decision points. The teacher explains that this computer game is designed to promote cooperative problem solving. (It's hard for one student to keep the necessary record, make the decisions, run the computer, and detect his/her mistakes all at the same time.) The game is also designed to help improve spatial orientation, record keeping, and following directions.

At still another computer station you see four students working together. They are playing a business simulation game. Each student is one of the partners in this fruit juice stand business. As they play the game they have to make decisions about how to spend their time and money. How much time should be spent on painting signs? How much fruit juice should they have available, and what should they charge? The goal is to make as much profit as possible. But all four students must agree on each decision before it is entered into the computer. When there is a disagreement, the students must work together until they agree.

At still another computer station you see a student working with some sort of program that allows the student to write, draw pictures, and work with databases. The teacher indicates that the student is using *LogoPS*, which was an outgrowth of the Logo software of the 1980s. In essence, it incorporates a word processor, a database system, and other problem-solving software into the "classical" Logo for microcomputers.

As you move away from the computers you almost trip over a group of students who are repeatedly throwing pairs of dice and recording the results on paper. The students indicate that the goal is to throw the dice 300 times and to see how it comes out. Sue has conjectured that the low numbers (2 and 3) will beat the high numbers (11 and 12). Tom has conjectured that there will be more sixes than anything else. Cathy has conjectured that there will be more even numbered answers than odd numbered answers. Karen has estimated that the four of them will complete the task in less than 10 minutes, and she is keeping one eye on the clock. She hopes that there will be enough time to do it all over again before it is time to do writing. She wants to write about how it comes out. (The teacher indicates that the students will be doing writing as soon as math is over. Often they are asked to write about what they are doing during other parts of the day, such as what they are doing in math.)

Before leaving the third grade classroom you get a chance to talk with the teacher. You ask how it is possible to keep track of what all the students are doing, and how it fits together in a curriculum. The teacher points to a computer, to a stack of activity recording sheets, and to a cabinet of materials. "The cabinet is full of manipulatives—for example, lots of sets of dice, bean sticks, 100s boards, tiles, spinners, timers, and other manipulatives. My computer keeps detailed records for each student. The students work together in groups of four, although one or two students will often split off from a group for a day. A group of four has considerable responsibility for itself and for its individual members. But each student has at least one individual session with the computer each week. In this session the computer asks a lot of questions about what the

student has been doing. It is sort of an interactive diagnostic test. The computer system offers suggestions on what the student might work on, and it gives me a detailed print out."

"I realize it all sounds quite complicated, but actually it is easy. Each day each group of four knows what it and its members are to be working on. Partly it is their own choice, partly the computer suggests what they might do, and partly I tell them what to do. When they use a computer it keeps track of what they are doing. When they do off-machine activities, I have them fill out these activity sheets. I feed that information to the computer, so it has a record of what the students are doing."

Needless to say, I was impressed! But I wondered about testing. "How do you give tests on all of this?"

The teacher indicated that no formal pencil-and-paper math tests are given in the third grade. The computer is gathering formative data whenever the student uses the computer. Since each student has at least one individual computer session per week, quite a bit of formative data is gathered. In addition, the teacher observes what the students are doing, and spends a lot of time working alongside the students. The role modeling is another important idea in math education. "It's fun--I get to do what the kids do, and I often learn new things or new ways of looking at the math I learned while I was in school."

I thanked the teacher, indicating once more that I was impressed by the changes from when I was in school. "Math looks like a lot of fun. Maybe if we had had these things while I was in school, I would have liked math."

Two Key Computer Related Questions

Scenario 1 is all based on ideas and technology that currently exist. While computers play an important role, the human element dominates. *Education is a human endeavor. In order to do mathematics it is necessary to carry in one's head a great deal of understanding about mathematics.*

However, it is clear that computers and related technology can play an important and increasing role in doing mathematics. Thus, we can think about a person:

- Doing mathematics making use only of his/her brain.
- But also making use of conventional aids such as book, pencil and paper, protractor, straight edge and compass, etc.
- But also making use of inexpensive and easily portable electronic aids such as a handheld solar powered calculator.
- But also making use of microcomputers (which may or may not be easily portable, but then again, they might be portable).
- But also making use of access to mini or mainframe computers, networked computer systems, telecommunications, large databases, etc.

In all of this we also have the issue of computer assisted learning. Thus, two key computer technology-related questions have arisen in mathematics education.

1. How should the content of mathematics education be changed to reflect the availability and capability of computers, calculators, and related aids to problem solving? This question focuses on:

   a. Use of calculators and computers as tools to help solve problems.

   b. Changes in the curriculum content, such as increasing the emphasis on exact and approximate mental math, geometry, statistics, and discrete mathematics, while decreasing the emphasis on paper-and-pencil computation and symbol manipulation, and rearranging the order of presenting various topics.

2. Can calculators, computers, and computer related technology help improve pedagogy in our mathematics education system? This question focuses primarily on use of computers as an aid to learning mathematics, or on CAL in its broadest possible definition. For example, use of a calculator as a manipulative in learning counting would be considered as CAL in this broad definition. But the question also deals with the use of a teacher-controlled computer with a display that can be viewed by the whole class. A Level 1 videodisc system (no computer, and the system may be under teacher control) is also included.

These are difficult questions and cannot be fully addressed in a paper of this length. However, the discussions, scenarios, recommendations, and appendices that follow provide a solid indication of some possible answers.

Computer Facilities: Hardware and Software Considerations

In planning for instructional use of computers in mathematics education, it is helpful to have some model of computer availability and capability in mind. The creation or selection of a model is a challenge, since both computer availability and capability are changing very rapidly. Almost every week one is apt to encounter news of a new product that is significantly better than the product it competes with. Over the past 30 years, progress in computer hardware has led to a price-to-performance gain by a factor of 10 roughly every seven years. There is good reason to believe this will continue for at least 14 more years. (The article *Personal Workstations Redefine Desktop Computing* by Jeffrey Bairstow on pages 18-23 of the March 1987 issue of High Technology discusses this in detail.)

People doing long-range planning for mathematics education should not dwell unduly on inadequacies of current computer capabilities and student access to these systems. Rather, they should assume that eventually every student will have easy access to a very powerful computer system. *The time frame necessary for making significant changes in our mathematics education system is sufficiently long so that during the same time frame computers will become readily available to all students (and others, such as workers and people in their homes) who have need to use them.*

People doing very long-range planning (10 - 15 years) for computers in mathematics education might want to assume that something like today's Macintosh 2, IBM PS/2 Model 70, or NeXT computers will be readily available to students. Let's call this a Mathematics Education Computer System (MECS). The needed software and courseware for MECS has four main components. While much of this software and courseware already exists in discrete components, it has not been drawn together in a unified manner. Thus, we should assume that the software and courseware facilities available for the MECS will continue to improve rapidly with time. The four components of this software and courseware are:

1. A mathematical reference library containing the equivalent of many hundred of books. Materials would be available for students at a variety of grade levels and mathematical maturity levels. This library would also contain instructional support materials for teachers, such as back issues of the publications of the NCTM, sample lesson plans, courseware developed by federally-supported projects, etc.

Note that one CD-ROM disc can hold 550 million characters; a thick novel is about a million characters in length. A CD-ROM can also store digitized pictures and diagrams. Thus, the above library can be stored on a modest number of CD-ROMs. (The cost of making a large number of copies of a CD-ROM, once an original has been produced, is under $2 each. A CD-ROM player has only a little greater complexity than a CD audio player. Thus, the price will eventually be in the $200-$300 range or perhaps lower.)

Texts written specifically for access via computer can be interactive. They can make provisions for moving more deeply into a particular topic, or backing off and looking less deeply into parts of it. (Ted Nelson called this concept *hypertext* when he pioneered it in the late 1960s. Hypertext is now coming into common use, mainly through a piece of software called *HyperCard* that runs on Macintosh computers.) A whole new style of writing will need to be developed, along with a careful cross-indexing system that helps guide readers through the wealth of available materials.

We already have the concept of dynamic texts. Data in a computerized database can easily be ordered, selected, graphed, etc. to meet one's specific needs. A spreadsheet program can take in data (perhaps from a computerized database), perform a variety of calculations, and display the results in a variety of formats. All of this is supportive of the idea that in mathematics education we need to have students learn to make use of multiple sources of information. *The fixed, static printed text that is changed once every six years cannot serve as the dominant basis for an Information Age mathematics curriculum.*

It is difficult to appreciate the benefits of having easy access to lesson plans, assignments, worksheets, exams, etc. in a computer readable form. This type of aid to teacher productivity is not yet available to most teachers. The effort of computerizing all of one's own filing cabinets of such materials is overwhelming. But imagine all of the "neat stuff" that master teachers have accumulated over the years. Then imagine a beginning teacher being provided with a CD-ROM of such materials. This would be a tremendous aid to most teachers.

2. Applications (computer-as-tool). This would include a basic core of general-purpose applications software, such as a two and three dimensional graphics package, a word processor designed to handle mathematical notation, a general-purpose equation solver, a statistical package, spreadsheet, database, and an algebraic symbol manipulation system. It would also contain many hundreds of more special-purpose programs designed to help solve more specific categories of mathematics problems. All of this software will need to be cross-indexed with the reference materials discussed above and with the computer assisted instructional materials to be discussed next. Eventually all three of these sets of materials will need to be integrated into one comprehensive system.

3. Computer assisted learning materials covering the K-14 mathematics curriculum. In addition to traditional CAL, this would include simulations that create problem-solving environments, logic proof checkers, and other interactive aids to learning and doing problem solving.

Very roughly speaking, CAL materials can be divided into the categories of "primary" and "supplemental." By primary, we mean materials designed to stand alone and be a primary resource to students studying a certain area. (Typically the CAL materials would be supplemented by a standard text or other print materials.) Much of the CAL math materials that now exists was

designed for supplemental use. For example, students might use drill and practice in arithmetic materials for ten minutes a day to improve their arithmetic computational skills. Students might use a piece of problem-solving software to practice a couple of heuristic methods in problem solving.

Several companies now market primary, full-year length CAL math courses for the secondary school math curriculum. In many cases the quality leaves much to be desired. The cost of developing a very high quality primary CAL year length course is probably in the range of $5-$10 million. While the potential seems good, the reality is that few if any really good CAL-based courses exist for precollege mathematics. (Some quite good pieces of courses exist.)

4. Programming languages and aids to computer programming. There are hundreds of programming languages, CAL authoring languages, CAL authoring systems, etc.

The past few years have seen a widening of the gap between "professional level" computer science and computer programming, and "personal" computer programming. It seems clear that a rigorous introduction to computer science and programming in a structured language such as Pascal will not become part of the regular precollege mathematics system. However, all students who can learn the regular mathematics curriculum can easily gain a modest, but highly useful level of personal programming skills. Such programming skills can be used to reinforce math concepts and to add another avenue for mathematical exploration. This has been amply demonstrated by users of Logo in elementary and middle schools and by users of BASIC at a variety of grade levels. (While BASIC is looked down upon with disdain by computer scientists, it will remain as a viable tool of many students and other computer users. Logo seems to be gaining acceptance at the secondary school level.)

It is evident that no precollege students currently have assess to the MECS hardware and software we have described in this paper. However, many scientists and engineers have access to a combination of computer facilities, libraries, and support staff that are roughly equivalent to MECS. *By the year 2000 many students will have access to a significant portion of this system. Moreover, mathematics education leaders could set a goal of making MECS available to all students.*

You will note that we have not mentioned calculators in this section. A calculator can be viewed as a special purpose, more easily portable, less expensive computer. The capabilities of handheld calculators have continued to grow. Very roughly speaking, the best handheld calculators of today are somewhat equivalent in compute power to low to medium priced mainframe computers of about 25-30 years ago, and this 25-30 year gap is being maintained over time. It seems clear that the handheld calculator will be with us for the foreseeable future. (If we want to be a little science fictionish, eventually the handheld calculator will become a voice input device that is part of the telecommunications system. It will be able to handle "simple" problems using its own compute power, and it will serve as both a telephone and as a terminal to mainframe computers, the Library of Congress, etc. Rapid progress in telecommunications technology is contributing to significant progress toward networking the world.)

Accumulated Mathematical Knowledge

Perhaps the single most important idea in problem solving is to build on the previous work of oneself and others. Mathematics, with its careful notation, precise definitions, and formal proofs is well suited to helping people build on the previous work of themselves and others. A student learning to count and to write the numerals is building on the work of those who invented counting and the notation we now use for numerals. (For most purposes, it is a far superior notation than Roman numerals.) Students who have learned how to count can use this skill in solving a wide range of problems.

The accumulated mathematical knowledge of the human race is, roughly speaking, in three general categories of storage and processing "media."

1. Human minds. Note that the human mind is both a *storage* and a *processing* medium. (Note the parallel with a computer.)

2. Books, journals, written notes, photographs, paintings, and other passive media that can be repeatedly accessed. Category 2 also includes phonograph records, tapes, movies, videotapes and other dynamic storage media that technological progress has produced in the past century. Still more recently we have magnetic tape, magnetic disk, and laser disc storage systems for computer readable data.

3. Artifacts that people use to help "do" mathematics. This includes tools such as abacus, slide rule, straight edge and compass, protractor, calculator, and computer. Pencil, paper, chalk and chalkboard can all be included in this category.

A protractor is an excellent example of a mathematical artifact. It embodies substantial mathematical knowledge. Most students can easily learn to make use of some of its capabilities to help solve problems. It is not necessary for a student to fully understand the mathematics embodied in a protractor, nor to understand all of its uses, to begin to make effective use of this tool. *A protractor, like many of the other mathematical artifacts, both stores mathematical knowledge and aids in processing or making use of the knowledge.*

A mathematics education system is designed to build on the capabilities and limitations of each of the three categories of storage and processing media. Any significant change to one of the categories may lead to a significant change in our mathematics educational system. For example, the development of reading and writing greatly changed Category 2 and certainly led to major changes in both the field of mathematics and in mathematics education. The development of movable type, another major change in Category 2 that eventually greatly increased access to books, changed mathematics education. In Category 3, solar powered handheld calculators have had a significant impact on adults and a more modest impact on our mathematics education system. Gradually the use of calculators has come to be accepted in school mathematics. Recent years have seen significant progress toward allowing use of calculators in state wide and other assessment settings.

Computers impact each of the three storage media. First, consider the human mind. We now have very good research evidence that computer assisted learning can help many students learn certain aspects of mathematics significantly faster and better as compared to traditional modes of instruction. Moreover, complete courses can be delivered by CAL, providing good quality learning opportunities that might not otherwise be available to students. Finally, CAL allows increased individualization of instruction, with students working on materials appropriate to their levels and moving at paces appropriate to their abilities.

One of the major goals of education is to help students become independent, lifelong learners. Most students never achieve this goal, especially in mathematics. CAL holds the potential for a shift of responsibility for learning mathematics more toward the student. CAL can provide good and immediate feedback on how well one is doing on a set of material. Students can learn to evaluate their own performance and begin to accept more responsibility for their own learning. This may contribute to helping the students to become independent, lifelong learners.

Category 2 contains both passive storage media such as books, and dynamic storage media such as phonograph records. It is evident that computers provide a new passive storage medium. Computers provide for the storage of a large amount of information in a small space. The

previously-mentioned CD-ROM is just 14 cm in diameter and the thickness of a phonograph record. But it can store 550 million characters—the equivalent of about 500 thick novels. (Imagine holding the equivalent of an entire elementary school library in the palm of one hand!) Moreover, computer technology facilitates easy access to remotely located databanks. We are moving toward the time when the entire United States Library of Congress is on line and readily available to people who need such access to information.

Computers provide a new type of dynamic storage, an interactive type of storage that is unlike anything we have had before. This is discussed more in the Category 3 discussion.

Category 3, artifacts, contains tools that aid one in doing mathematics. We now have the possibility of students growing up with the computer tool. It seems evident that growing up in a MECS environment will shape students' minds in a manner quite a bit different from what occurs in a non-computer environment. For example, consider computer graphics. Without computers it takes considerable effort and training for a student to represent data or functions graphically. Even a single, crude sketch of a function or a set of data can easily take minutes to produce. Animation is quite difficult to depict in hand drawn sketches. With MECS, graphing a function or a set of data becomes a "primitive" that is usually accomplished in less than a second of computer time after the task has been specified. Students using MECS can create graphical representations of data at a younger age than they can without this tool.

Or, consider solving equations (polynomial, non-polynomial, linear systems, nonlinear systems, etc.). The value of computers is obvious. Many time consuming and tedious tasks become primitives, routinely accomplished both rapidly and accurately by the computer, as one works to solve mathematics problems.

Or, consider linear programming and nonlinear programming. Students can learn to use these tools for mathematical modeling long before they can learn the underlying theory of solving such problems. Computers are already routinely used by all people who solve such problems.

The above analysis illustrates the most obvious ways in which computers impact the storage of accumulated mathematical knowledge. But there is still another, even more important idea. *Computers represent a new, dynamic way to store some of the processes of applying human knowledge. In essence, a computer system is a medium combining the second and third storage categories. An application program designed to solve a particular category of problem both stores human knowledge on how to solve the problem and directs hardware to carry out the steps to solve the problem.*

Research and development in artificial intelligence are gradually producing computer systems that capture some of the problem-solving capabilities of human experts. Progress of this sort tends to be cumulative. Thus, more and more mathematical problems will be solvable by merely telling the problems to a computer. This topic deserves a much more detailed treatment than we can provide in the limited space available here. Over the long run, progress in artificial intelligence may well change the basic nature of mathematics education. Students will grow up in an environment in which they learn to communicate with a computer system (by voice and keyboard) that has immense mathematical knowledge and ability to solve mathematical problems.

The most important idea in this section on Accumulated Mathematical Knowledge is that a computer can be used to retrieve information and procedures telling how to solve a problem, and it can also execute the procedures both rapidly and accurately. In essence, this adds a new dimension to mathematics education. This will be made clearer in the next section.

A Simple Model of Mathematical Problem Solving

In this section we present a simple-minded model of problem solving in mathematics. (In essence, this is the standard four-part Polya model that math education leaders have been supporting for years.) The purpose is to point out the main places where the MECS will impact people who use mathematics to solve problems. A secondary purpose is to suggest some possible major changes in emphasis in various parts of the mathematics curriculum.

1. *Understand the problem.* This may require making use of reference materials, and MECS will be useful. But to a large extent, understanding a problem requires drawing on one's total knowledge, asking probing questions, and interpreting problem situations in light of human values. It is a human endeavor, drawing heavily on the total interdisciplinary knowledge and skills of the problem solver. Often it requires good interpersonal communication skills.

A key point is that the typical "real-world" mathematical problem is interdisciplinary in nature. One must know both about the disciplines of the problem and about mathematics to understand such a typical real world problem. Currently, many academic disciplines such as the social studies make minimal use of mathematics in their curricula. MECS provides tools that could change that. Increased application of mathematics throughout the school curriculum would make a significant contribution to mathematics education.

2. *Develop a mathematical model of the problem.* To a large extent, mathematical modeling is an intellectually challenging human endeavor, drawing upon one's total knowledge of mathematics, the disciplines and specific nature of the problem at hand, and experience in mathematical modeling. The MECS may be useful for information retrieval (for example, retrieving models that might be appropriate), drawing graphs and other pictures, word processing, etc.

MECS changes the range and nature of models available. Students can learn to use linear and nonlinear equation models, linear and nonlinear programming, etc. without knowing how to solve such problems using by-hand methods. Models can be used that require exhaustive search of rather large solution spaces. Statistical models can be used that require extensive computations or exhaustive searches. Graphical models can be used because two and three dimensional graphing is easily accomplished by computer. MECS has the compute power and graphical capability to do animation and color graphics.

3. *Solve the mathematics problem developed in the previous step.* Quite likely the MECS can do this or can make a significant contribution in doing this. Often this step is somewhat mechanical, and it is the step most conducive to being automated. (When secondary school math teachers are asked to examine the curriculum they teach, they typically estimate that between 60% and 80% of the curriculum focuses on this step.)

4. *Interpret the results in light of the original problem.* Return to Step 1 as needed. This mathematical "unmodeling" and interpretation process has the same characteristics as Step 2. It is a human endeavor requiring good understanding of the original problem and good thinking skills.

Even this simple model of mathematical problem solving makes clear that mathematics is and will remain a human endeavor. This model, and the discussion of the Accumulated Mathematical Knowledge, make it clear that one must "know" a lot of mathematics in order to "do" mathematics. But the doing of mathematics is highly dependent on the tools available and how well one has

learned to use the tools. That is, learning to do mathematics is inextricably interwoven with learning to use the tools available to mathematicians.

Educators talk about a concept called "the teachable moment." Imagine a person working to solve a mathematics problem but not having the knowledge and/or skills needed to handle some aspect of the problem. We can imagine that the person might move from a problem-solving mode into a CAL study mode to learn some aspect of the problem, and then back into a problem-solving mode. This would be taking full advantage of a teachable moment. It represents a significant change in mathematics education which could help narrow the gap between learning mathematics and doing mathematics.

But there are two other key ideas evident from this simple model of problem solving. One is the idea of information retrieval. For many reasons we currently do a relatively poor job in helping students learn to use mathematics reference materials. The availability of MECS could (would) provide a strong incentive to make significant changes in this aspect of mathematics education. *An increased emphasis on information retrieval in the mathematics curriculum would help move math education into the Information Age.*

The second major possible change comes from Step 3 above. Computers can execute algorithms quickly and accurately. The basic nature of the human brain is that it is not good at exact memorization and at doing repetitive tasks requiring extreme accuracy. It "forgets," or becomes bored, or just plain makes an occasional error.

The types of abilities that lead to excellence in doing repetitive computations or symbol manipulations seem only vaguely related to the higher-order, problem-solving skills that we want students to gain through their mathematical studies. Indeed, it could well be that the emphasis on developing such skills is one of the roots of the "I can't do math and I don't like math" outcome that is so frequent in our mathematics education system.

The concept of an "inverted" curriculum has arisen from the type of analysis given in this section. In essence, the use of a computer to execute algorithms facilitates teaching students to use a computer to solve certain categories of problems without teaching them either the underlying theory or how to do the computations by hand. We currently have little research to help us understand possible effects of using a computer based inverted curriculum. But there are quite a few non-computer based somewhat analogous situations in our current curriculum.

The protractor was emphasized in earlier in this paper because it illustrates some of the inverted curriculum ideas. Similarly, we teach grade school students to make use of a zero and a decimal point; both of these represented major breakthroughs in mathematics, and their underlying theory is well beyond students who are first learning their use. The ideas of a function and of functional notation are introduced rather early in our mathematics curriculum. These are deep mathematical concepts, perhaps only fully understood by people who have both good mathematical ability and who study the subject for many years.

Note that "cookbook" statistics and other math-application courses existed before computers became available to students. The use of computers in such courses has been common for many years. In many ways a cookbook statistics course represents a type of inverted curriculum.

We have not discussed possible applications of artificial intelligence in mathematics education. The MECS we have described is powerful enough to execute the artificial intelligence software that currently exists or is under development. More and more problems will be solvable by merely accurately specifying (describing) the problem to a computer. The computer will interact with the problem poser to assist in this accurate specification process. The potential impact on mathematics education is not clear.

One of the early attempts to apply artificial intelligence ideas to arithmetic instruction was the program *Buggy* developed by John Seely Brown at Zerox's palo Alto Research Center. The goal was to develop a program that could detect and classify student subtraction errors, and then provide appropriate remediation. The program wasn't as useful as might have been expected, because of the nature of the human mind. Students tend to make random errors. At one moment they will demonstrate that they can perform a certain type of computation, and a few minutes later they will fail in an attempt to do a nearly similar computation. It seems clear that we need a learning theory that better reflects the frailties of the human mind.

Scenario 2: Middle School

12 September 1999

To Whom It May Concern:

I have been informed that I have been nominated for Teacher of the Year and that I should write a letter supporting this nomination. I am embarrassed to write about myself, but here goes!

I am 61 years old and have been teaching for 32 years. I have three children and five grandchildren. I began as an elementary school teacher in 1960. About fifteen years ago I decided to take my present position, which is teaching all of the middle school students (grades 6-8) in a small rural school. Our school has four teachers, covering grades K-12.

I graduated from college in 1960, which certainly seems like a long time ago. My major was elementary education and I specialized in reading. I have always enjoyed books, and I am good at looking up information in a library. I focused on primary school education because I wasn't sure I could handle the math in the upper grades.

My first teaching assignment was in second grade. I stayed at that level for several years. Then I attended a math workshop which placed special emphasis on use of manipulatives. For the first time I began to understand that math was more than just doing arithmetic, and that math could be fun. I immediately changed my math curriculum to reflect what I had learned. I think we used a book called *Math Their Way*.

During the next dozen years I taught at most of the elementary school grade levels, but with several years off to have children. I learned quite a bit about science and math, but I continued to focus mainly on language arts. It has always seemed clear to me that reading and writing are at the very core of education. I taught all of my students to have good library-use skills. Even when I was teaching math, I emphasized learning to read the math book.

In the mid 1970s I attended a National Science Foundation inservice that focused on use of calculators and computers. Well, we certainly didn't have any computers in our school—indeed, the only calculators were in the main office. But I bought an electronic calculator and began to experiment with it in my fifth grade class. I let students use it to check answers. Also, students could play with it as a reward for getting their math assignments done quickly and neatly. They had fun making up problems so that when the calculator display was turned upside down it spelled out a word. But, all in all, I was not impressed by such silly uses of this machine.

In 1980 I managed to talk my principal into buying a classroom set of calculators. We got solar powered calculators, and they cost about $25 apiece. I guess that was when I really began to get interested in math. I was teaching sixth grade then, and my students had already had quite a bit of instruction in paper and pencil arithmetic. I decided to let them use calculators whenever they liked, and I began to focus on problem solving. I remember that some of the parents got quite unhappy. But there was an article in the Arithmetic Teacher (December, 1980, by Grayson Wheatley) that gave research supporting my position. And then the *Agenda for the 80s* came out, and it supported my position.

I moved to my present position in 1985. (My husband is the school principal and teaches part time.) This year I have five sixth graders, four seventh graders, and seven eighth graders. Let me tell you about a project we are working on, since it will give you some idea of how I teach. Each year we spend a whole lot of time on just a few projects. Some of the projects, such as the one I will describe, continue year after year.

The project began several years ago when I first learned about acid rain. It seems like acid rain may be damaging the trees and crops in our community. So, we began to talk about this in my classroom. All of my students expressed some interest in this topic, so we decided to build a unit of study around it. We approached it from a problem solving point of view with all students working together, as we do for almost everything in my classroom.

I know that I am supposed to allocate a certain number of minutes a day to math, science, language arts, physical education, etc. But I just don't follow these rules very closely. (I do make sure that each student gets an hour a day of drill and practice on "basics" on the computers, covering math facts, spelling, vocabulary, geography, and so on. This hones their fundamentals and ensures they will do well on the standardized tests that they have to take.)

The class and I decided to spend our physical education time going for walks in the woods and fields, seeing whether we could detect changes that might be due to acid rain. The kids began to gather tree leaf samples, as well as samples of various crops. They thought that maybe we would be able to see a change from one year to the next.

We used our computer to search periodicals for articles about acid rain. It seems like this is a problem going back to the 1980s, so we looked up and read a number of old magazine articles. One of the things that we learned is that the Canadian and US governments have been arguing about whose industry was causing acid rain, so I had my students begin to read about this. Each student had to write a paper on how different countries resolve such issues.

We learned a lot about the Industrial Revolution, competition among companies and countries, and how hard it is to figure out who is to blame. I had my students study the rapid growth of manufacturing during the industrial age and write reports on what they were learning. They had some trouble understanding the big numbers used to describe company sales and profits. So, we spent quite a bit of time on economics and how companies work to make a profit. We made use of a business simulation game—the kids played it for several weeks.

Meanwhile, we had all of the stuff they collected in the woods and fields. We decided it would be a good idea to measure the tree leaves and to find their areas. But it soon became evident that there is no simple formula for the area of a leaf, and that each tree had leaves that differed widely in size and shape. This lead us into studying some statistics. Soon I had all of the students attempting to gather a "random sample" of leaves from various trees. We build templates for measuring the length and width of a leaf. Students learned to find area by tracing a leaf on graph paper, and then counting the number of squares. We recorded our data in a computer database. We used the computer to calculate means and other statistics. We also printed out graphs relating length to area, width to area, tree type to average area, etc.

A neat thing happens when you have students of several grade levels working together. The kids that are good at something help the others. When they can't help each other, then I get involved in providing the help. But usually I let them muddle around, trying to figure it out for themselves. We have a lot of good computer assisted learning materials. The older kids often direct the younger kids to CAL materials that they found particularly useful. In some ways this combination of older kids and computers is like having a half dozen teacher's aides.

It turns out that lots of people are interested in acid rain. We sent away for a kit that allows us to measure the acidity of rain. We built a weather station and spent quite a bit of time studying weather. We set up rain gauges in a whole bunch of places, since there is quite a bit of variation in a region. This way each student was responsible for maintaining one rain gauge, and reading it each time it rained. We got a contest going, to predict how many cm of rain we would have in each of the months remaining in the school year. I showed students how to look up rainfall data from previous years for our part of the state. They used data from the past 20 years to help them make their

estimates. Interestingly, although they all had the same data, they all came up with different estimates. We spent quite a bit of time discussing this.

But we had to do something with all of that data we were gathering, so we got involved with the computer again. We decided that we wanted a program that allowed us to type in the data from all of the rain gauges, and that would print out a map showing this data. We also wanted the program to calculate the total amount of rain that had fallen in the circle which is three kilometers in radius and centered on our school. I usually have a couple of students who are good at programming. Three of them worked together to make a program that takes in the data, prints out a map, and calculates total rain. The first year they did this they entered it in a science contest and won second prize. I was really proud of them!

I went to a conference and found out that there is a computer network of people interested in acid rain. I got our school involved, and I told them about our leaf measurements. We got tied in with several schools in other states and a couple outside the United States. We had them gather data about the tree leaves in their area, and we created a large database with all of that data.

I suppose that project is why I have been nominated to be a Teacher of the Year. We have been working on it for ten years, and it has gotten quite a bit of publicity. I even wrote an article on it, and it got published. Each year my students spend quite a bit of time on this project. We plot multi-year year trends, and we think of new ways to analyze the data. Each year we also think of additional data to gather.

I could go on about other projects, but you have the general idea. We make a lot of use of computers, and I spend a lot of time working with my students. They learn all kinds of things that I don't know much about, since they all get good at looking up stuff in the computer information retrieval system. We learn together, and I feel that is what education is all about.

Sincerely yours,

Mrs. Sally Jones

Scenario 3: High School

3 November 2000

Dear Diary:

I can't tell you how much fun I had today. And I thought it was going to be a bummer!

Today was parent's day at my twins' school. Kay and Ken informed me that if I attended, they wouldn't have to go to school that day. What could I say? Fortunately, they said I didn't have to go to the physical education class. They said that I was too old for gymnastics.

So, off I went, quite prepared to suffer through the day. And, wouldn't you know it, the first class was Second year Conversational Japanese. I have picked up a couple of words from the kids, but I am not sure what they mean. They are always jabbering to each other, so I guess they have learned a lot.

Well, in I went, and the teacher greeted me in rapid fire Japanese. I mumbled something about Kay and Ken, and hurried to a back corner of the room.

The teacher noticed my discomfort and suggested that I might like to play with the CAL videodisc lessons. The classroom has one MECS per student, each equipped with a videodisc player and earphones. The teacher got me started with lesson 1, and I soon

become engrossed. The pictures were amazing, but what was most amazing was the voice input system. The computer system would pronounce a word and display its voice pattern on the screen. Then I pronounced the word, trying to match the voice pattern. The computer provided feedback on how well I was doing, and it even made some suggestions on how to do better! The class period passed quickly, and soon it was time to go on to the First Year Physics class.

I thought I would be more comfortable in physics, since I had that course in high school. But what a change! It was a lab day, and the students were doing an experiment about acceleration. They had a little device that they said was like the auto focus mechanism in a camera. It measured distance quickly enough so that it could give good data on a moving object, such as a falling weight. It fed the data into a computer.

The students then used the computer to fit a curve to the data. They said they were doing a "least squares" fit, and that this made use of calculus and solving linear systems of equations. I asked them if they understood the calculus. They replied that they hadn't studied calculus yet, but that it wasn't necessary to understand calculus in order to understand fitting a function to some data.

By the end of the period, some of the students were beginning to write up their lab report using the word processor on the computer. They explained that they were using an integrated package, so that they could incorporate the experimental data, as well as some graphs produced by the computer. One of the students showed me a computer printout of the data and the function the computer had fit to the data. It looked like a parabola to me.

Third period was Current World Problems. I was a couple of minutes late, since I got lost in the hallways. By the time I got there a couple of the students were reporting on their most recent electronic mail "conversations" with students in Russia. It turned out that each student in the class has an "electronic mail pal" in another country. Part of the required work in the course is to write monthly reports on the ideas discussed with their electronic mail pals.

After a couple of brief reports, the teacher engaged the students in a discussion on where in the world one might most expect to find quite a bit of terrorism. I guess this was a long term project, since the students seemed to make frequent references to discussions in previous days. It was interesting how they used computers in studying this question.

The students had a computer database listing all countries in the world, with a number of characteristics of each country. For example, the database contained information on population, fertility rate, area, average number of years of schooling, per capita income, form of government, percentage of the population with various religious beliefs, and so on.

Initially the teacher reviewed how one might find relationships between sets of data. The teacher demonstrated use of the computer to graph pairs of data, such as per capita income versus fertility rate. The class made conjectures on what relationships one might expect to find (for example, low income being associated with high fertility or with low life expectancy) and the teacher helped them graphically explore these ideas.

Students were then assigned to work in groups of three, using the MECS in the room. The assignment was to make at least five somewhat related conjectures, test them using graphic techniques, and write a brief report on the findings. The students were to share in developing the conjectures, but each was to write their own report interpreting the results. I could see how this work tied in with making conjectures about factors related to terrorism.

Fourth period was math, and I was really bushed by then. I don't see how the kids can handle so many hard classes, back to back. I had been looking forward to the math class, since I was a math major my first two years in college. That was before I decided to be a business major and to go into the insurance business.

I noticed that there was a MECS at each student desk. As students came in they immediately flipped on their computers and set to work. I asked the teacher what they were doing. The teacher explained that the first ten minutes of each math period were devoted to playing some simulation game or practicing some basic materials students have studied in the past. This is part of a carefully designed, systematic review and reinforcement schedule which helps improve long term retention of the math students have studied. It also gives students feedback on areas where they need to do more review or further study.

Today's game was a quite old piece of software called *Super Factory* (from Sunburst Communications). In it students get to see several views of a cube with different pictures on some of the faces. Then they have to direct the computer in creating a cube which looks just like the original. The teacher explained that playing the game helps many students to improve their three dimensional visualization skills.

After ten minutes the teacher flipped the power switch to the student computer display screens, and turned on the power to the classroom computer display. The teacher indicated that the lesson for the day was on use of mental skills and computer graphics to solve equations with one unknown.

The teacher asked for some examples of equations that couldn't be easily solved mentally. Various students provided suggestions, and the teacher typed them into the computer so the equations were displayed on the screen. For example, the students suggested problems such as:

$$3x^2 - 15x^{1/2} + 6 = 0$$

$$4\sin(x) - 2x^3 + 5x - 12.8 = 0$$

$$2^x - 25x + 3 = 0$$

$$x^{1/2} + x^{1/3} + x^{1/4} - 9 = 0$$

For each equation, the teacher discussed how one might be able to mentally figure out if there is a solution or more than one solution. For example, on the first equation when $x = 0$ the function is positive. But when $x = 1$, the function is negative. So, the equation has at least one root between 0 and 1. [*Editor's Note*: This assumes that the function is continuous in the interval with end points 0 and 1.]

After an equation was discussed, the teacher had the computer graph it, and then showed how to read off the places where it crossed the x-axis. The teacher also suggested that a problem such as the second one might better be handled by graphing the following two functions, and seeing where they intersect.

$$y = 4\sin(x)$$

$$y = 2x^3 - 5x + 12.8$$

The computer system had a "zoom" capability that allows the teacher to use a mouse to point to a part of the graph, and to have that part be expanded. This can be used to investigate a pair of equations in very fine detail, to see if and where they intersect.

I am afraid that I got carried away, since I raised my hand and was called upon. I said, "All of those examples look too easy, and they certainly aren't the type of problems I have to solve in my insurance business. Why not try a real world problem? For example, suppose that I deposit $800 at the beginning of each year for five years,

and I want to have $5,000 at the end of five years. What does the interest rate need to be, if interest is compounded at the end of each year?

The teacher appeared delighted by the question, and said to the class: "Here is a real world problem. How many of you think that you would be able to solve it by the end of the period?" A couple of students thought they might be able to do so, but most indicated they had never seen as problem remotely like that before. Upon further prodding, most indicated that they knew about compound interest, but didn't know a formula for this problem.

The teacher then turned to the chalk board and began to think out loud about the problem. "Let's use x as the interest rate. If the interest rate were zero, I would only end up with $4,000. That suggests that the problem makes sense. The interest rate needs to be large enough so that all of the interest adds up to $1,000.

"Suppose I had the whole $4,000 at the beginning, but it was just invested for 2 1/2 years. An interest rate of 10% would give me more than $1,000 interest. My guess is that the answer will be a little less than 10%."

"If I deposit $800 dollars at the beginning of the first year. I will have $800(1+x)$ dollars at the end of the year. Those original dollars will become $800(1+x)(1+x)$ by the end of the second year, and $800(1+x)^3$ dollars by the end of the third year. Meanwhile, of course, I have the added amount of $800 deposited at the beginning of the second year, and it begins to earn interest. Aha! I am beginning to detect a pattern I am now sure that I can solve the problem."

The teacher then turned on the student computer display screens and indicated which file contained equations to solve using computer graphics. The teacher assigned my problem as extra credit.

Near the end of the period the teacher asked if anyone had been able to solve my problem. Several students indicated they had, and their answers were fairly close together. One student indicated, "I figured out the equation, and it had a bunch of $(1+x)$s raised to different powers in it. I graphed it, and read off an answer. Then it occurred to me that I could use the computer to simplify all of those powers of $(1+x)$. I used the symbol manipulation program to do it, and I got an ordinary fifth degree polynomial equation. I had the computer graph it, and I got the same answer as before. Then I used the polynomial solver, and the answer was about the same. I am confident that it is right."

Another student indicated that she had tried to look up a formula, but hadn't been able to find one. "I found information about this type of problem. It is called an annuity problem. The computer gave an equation like you started to develop , but it used **i** instead of **x** for the interest rate. And there was no formula for finding the answer. I thought that our computer had a formula for just about everything. Did I look in the wrong place?"

The teacher indicated that there aren't any formulas for most problems. "Finding or developing an equation to solve, and having a computer to help do the work, is a more general approach. That is why we are working on general methods for solving equations, such as using computer graphics."

Needless to say, I was impressed! We certainly didn't learn to do things like that when I was in school. As I started to tell what things were like in the "good old days," the bell rang. I played hooky for the rest of the day, since I had to meet a client for lunch. But I'll remember this day for a long time.

Recommendations and Closing Comments

The basic recommendation is that mathematics educators and researchers work to create a MECS mathematics education environment for students. We have described a framework for change, and it can serve as a basis for long-range planning. The following five important steps need to be pursued concurrently and iteratively.

R1. Develop the hardware, software, and courseware of MECS and work to make the entire system cheaply and readily available to students. Begin orienting students to their responsibilities in a MECS learning and work environment.

But note that most of the ideas that we want to teach using MECS can be taught with the types of computers, textbooks, and libraries currently available in most schools. We can begin now, rather than waiting until MECS is available.

R2. Provide appropriate training to existing and new teachers. This will require a massive amount of inservice training as well as changes to our teacher training programs. Increasing, the role of CAL will change the role of teachers—perhaps to more of a mentor or facilitator role.

Most teacher training institutions have made some progress toward providing preservice teachers with a little introduction to computers. But in most cases this instruction is not adequate to prepare teachers to deal with the math curriculum of the year 2000 and beyond envisioned in this paper. The computer needs to be integrated as an everyday tool into a large number of the college classes taken by preservice teachers. Both primary and supplemental CAL needs to be available and routinely used in a variety of these courses.

R3. Begin both the development and the concurrent research on curriculum appropriate to a MECS environment. Be fully aware of the use of MECS as an interdisciplinary tool. Math is important in many fields of study.

The process of research and implementation needs to occur concurrently if the overall task is to be accomplished in a timely fashion. A lot of research and curriculum development has already been done on interdisciplinary aspects of mathematics.

R4. Begin modifying teacher-produced, district-wide, state-wide, and national assessment to reflect and take advantage of a MECS environment.

In many ways, our national assessment instruments drive our mathematics education curriculum. We should move rapidly toward a situation in which both calculators and computers are made available to students during testing.

Perhaps the key idea is that one major goal is to prepare students to do mathematics in the environment they will encounter after leaving school. This environment will include ready access to calculators and computers. Thus, both instruction and testing should (for the most part) be done in an environment of calculators and computers.

R5. Begin working to gain the support of all of the people who must be involved in the changes needed to have mathematics education occur in a MECS environment. This includes students, parents, school board members, teachers, educational leaders, legislators, textbook publishers, etc.

Research on change in education strongly supports the need for long-range planning that involves all of the key stake holders.

We close this paper with a number of comments related to the ideas presented earlier. Many are points that require additional discussion and/or research.

C1. Computer facilities somewhat equivalent to MECS will increasingly become available to people in business, industry, government, and research. We know quite a bit about transfer of learning. We know that transfer of learning is greatly helped if the learning environment and the applications-of-learning environment are quite similar. This provides a strong argument for integrating the use of MECS into our mathematics education curriculum.

C2. Students vary widely in their mathematical abilities. Mathematics education is designed both to help students to work up to the levels of their mathematical abilities, and to sort out those those with greater or lesser abilities. Those with greater abilities are encouraged to seek mathematically-oriented careers, while those with lesser abilities are steered in other directions. But the sorting out process is often flawed. For example, students with poor ability to memorize computational and manipulative algorithms and to develop both speed and accuracy in their applications may be discouraged by our current mathematics education system, but we know that many such individuals have great mathematical ability. Education in a MECS environment might be of great help to people with low innate computational skills.

C3. Except in a few physical science courses, most current non-mathematics courses make very little use of mathematics. That is a sad and sorry situation, since mathematics is useful in every discipline. The MECS tool has the potential to change this situation. Curriculum reform is needed in many disciplines.

C4. For many people mathematics is a "game" to be played by certain rules. Thus, use of a calculator is "cheating." It is evident that widespread availability and use of MECS changes the mathematics game. One can expect resistance to such changes. Quite a bit of the resistance will likely come from those currently playing the game quite successfully, including many math teachers. On the other hand, quite a bit of encouragement for the change may come from people who apply math on the job, such as scientists and engineers. For them, math is less a game and more an indispensable tool for solving the problems they encounter on the job.

C5. Our mathematics education system is used to tools such as the compass and protractor. Such tools change very slowly, if at all, during a person's lifetime. Our mathematics education system is not used to rapidly changing tools. Mathematics education, especially at the precollege level, is built on content that may change little during a person's teaching career, and on methodology that changes but little over several decades. Thus, our mathematics education system is basically conservative in nature. This suggests that it will be quite difficult to move this system in the direction of the MECS environment.

C6. Color displays and motion graphics add new dimensions to the tools available to students and teachers. We know little about appropriate uses of such tools. Research is needed.

C7. We have made only brief comment on the teaching of computer programming and computer science. These are topics that are related to change in mathematics education, but are not at its core. Computer science is a discipline that is somewhat distinct from mathematics. However, mathematics educators may decide that it is advantageous for all mathematics students to learn to program. They might decide there should be a computer programming strand in the mathematics curriculum. That is a good topic for another paper.

Computer science places considerable emphasis on the development and representation of algorithms, on analysis of possible performance of algorithms, on programming algorithms, and debugging programs. All of these ideas are quite mathematical in nature. Studies on factors predicting success in computer programming courses invariably identify mathematical knowledge and ability as key factors. That is, computer science and mathematics are closely related disciplines. Many colleges have chosen to combine these disciplines in a single department.

C8. The ideas proposed in this paper will require many decades to implement. But a significant start can occur in the next ten years. The microcomputers currently available in schools are powerful enough to begin the change to a MECS mathematics education environment.

C9. The proposed changes to the precollege mathematics curriculum will create a major articulation problem with the college curriculum. It is essential that the precollege curriculum revision effort be paralleled by a college mathematics curriculum revision effort.

C10. MECS, and the ideas discussed in this paper, could revitalize mathematics education. It could bring new life and excitement to mathematics students, faculty, researchers and writers.

PART 2: EFFECTIVE INSERVICE PRACTICES

Chapter 2.1
Effective Staff Development for Teachers: A Research-Based Model

Part 2 of this book is divided into three chapters. The first chapter contains all of the content of the report:

> Gall, Meredith D. and Renchler, Ronald S (1985). Effective Staff Development for Teachers: A Research-Based Model. Published by the ERIC Clearinghouse on Educational Management, College of Education, University of Oregon.

The Gall and Renchler report focuses on inservice to promote basic skills. However, it provides an excellent summary of research-based effective inservice practices, and it provides a model for the study of effective inservice practices. Moreover, since there is relatively little research literature specifically on inservice for computer integrated instruction, it seems appropriate to investigate the more general inservice literature, and then consider its implications for CII inservice.

The second chapter discusses some of the literature on computer integrated instruction inservice as well as some other literature that might apply to this type of inservice. This chapter contains all of the contents of Chapter Two of the doctorate dissertation:

> Johnson, Vivian Patricia (1988). An Exploratory Case Study Describing the Long-Term Residual Effect of the Computer Integrated Instruction (CI^3) Project. University of Oregon.

The third chapter lists a number of questions that are raised by CII inservice providers. Some key ideas and options underlying each question are discussed.

Effective Staff Development for Teachers: A Research-Based Model

Meredith D. Gall and Ronald S. Renchler
in collaboration with Fay B. Haisley, Robert G. Baker, and Miguel Perez

**ERIC Clearinghouse on Educational Management,
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FOREWARD

At a time when teachers, administrators, and local and state policy-makers are taking concerted steps to improve school effectiveness, the quality of staff development programs for teachers is a logical concern. At a time also of limited funding for schools, those who design and implement staff development programs want to make sure that the resources allocated to those programs achieve the results intended.

What practices distinguish effective staff development programs for teachers from those shown to be less effective? When school districts design and implement staff development programs, do they actually use practices that have been proved effective?

In 1982, a team of researchers from the Center for Educational Policy and Management at the University of Oregon sought answers to these two questions. The team first examined the research literature to identify effective inservice practices. A practice was considered effective if it could be shown to have at least one of three results: teachers incorporated the content learned from the staff development program in their classroom instruction, teachers and administrators were satisfied with the program, and students improved their achievement in the basic skills. In a second stage, the team surveyed teachers and administrators to see whether actual inservice programs utilize these research-validated practices.

The results were disquieting. Most of the staff development programs bore little resemblance to the list of effective practices that emerged from the literature review. For example, according to the research, the most effective programs are designed for the purpose of school improvement. But in actual practice, the survey showed that 67 percent of staff development activities are for teachers' personal professional improvement. The activities also paid little attention to student achievement as a desired outcome, pursued many goals instead of a few priority ones, and neglected direct instruction strategies. All these characteristics are contrary to the recommendations emanating from research on effective staff development programs.

A primary mission of the ERIC Clearinghouse on Educational Management is the dissemination of research findings in formats that facilitate their implementation in schools. Accordingly, the Clearinghouse is pleased to publish this monograph on effective staff development programs. The main portion of this monograph is a revised and updated version of the literature review mentioned above. We thank the Center for Education Policy and Management for giving us permission to use this material, originally published in The relationship Between Inservice Education Practices and Effectiveness of Basic Skills Instruction, by Meredith D. Gall, Fay B Haisley, Robert G. Baker, and Miguel Perez (197 pages, December 1982). Copies of this report are still available from CEPM for $5.00 each; it is also available from EDRS (ED 228 745) in paper copy ($16.15) and microfiche ($0.97).

The research review has been brought up to date to include several studies made available since the original report was published. Another change is the addition of case studies of exemplary school district staff development programs.

Meredith D. Gall codirected CEPM's research project and wrote the original report. He is professor of education in the division of Teacher Education, College of Education, University of Oregon, and is research associate in the Center for Education Policy and Management. His areas of specialization include instructional design, performance-based teacher training, and the effects of

teaching. His most recent research involved an NIE-funded project that examined principals' participation in teachers' staff development.

Ronald S. Renchler is a freelance analyst and writer who was employed by the Clearinghouse to revise the literature review, in collaboration with Gall, and to write the case studies.

At the time of the project, Fay B. Haisley was associate dean for teacher education in the College of Education, University of Oregon. As project codirector, she contributed to the design of the research, recruited sites and personnel, and provided administrative support. Haisley is currently dean of the School of Education, University of the Pacific.

Robert G. Baker and Miguel Perez, at the time of the project, were doctoral students who assisted in data collection and analysis, among other duties.

Stuart C. Smith
Director of Publications

Introduction

One result of staff development programs for teachers should be an improvement in the quality of their classroom instruction. But the path leading from the design and implementation of inservice programs to improved teaching skills to better performance by students often seems to wind through the wilderness. Unfortunately, few established signposts are available along the way to provide guidance. It is understandable, therefore, when those involved with inservice programs become lost while trying to find a clearly marked thoroughfare leading to school improvement.

Perhaps we need a map. Even though we might occasionally become lost, with a map we can retrace our steps and find out where we took a wrong turn. We can begin our map-making by first identifying the numerous elements that are involved in designing an effective inservice program.

No one yet pretends to have discovered all the elements that make staff development programs completely successful. We hope, however, that the map, or model, presented in this Digest will provide administrators and teachers with a set of essential elements and principles to consider in using inservice programs for school improvement.

There are, of course, many purposes for staff development. Among them are professional and personal development of teachers; specific teaching methods; special skills for teaching handicapped and gifted students; curriculum implementation; and basic skills programs. Because much attention has been given recently to improving students' basic skills, the model presented here is based on that purpose. It should be apparent, however, that with only minor alterations, the dimensions and practices identified as important for successful basic skills inservice programs should be applicable to virtually any type of inservice program.

Our model comprises 27 dimensions that we identified as important elements of effective inservice programs. We used a review of the research literature on basic skills instruction at the elementary school level to derive a set of generic dimensions for characterizing inservice programs. A summary of this literature review is given in Appendix A.

A second literature review focused on reports on the effectiveness of inservice programs that used practices corresponding to the dimensions in our model. From this review, we identified four inservice experiments that led to an improvement in students' basic skills achievement. These experiments are referred to collectively throughout this report as "the four inservice experiments." Appendix B describes the four inservice experiments.

The 27 dimensions, the effective practices associated with each dimension, and the research basis for validating their effectiveness are described in Table 1. The first column of the table lists the dimensions and the six categories under which they are organized. The second column lists an effective inservice practice associated with each dimension. In a few cases, an effective practice could not be identified. The third column identifies the type of research from which the effective practice was derived. Programs can use the table to compare their own inservice practices with the given standards.

The chapters that follow provide a full description of each dimension, a discussion of effective practices associated with the dimension, and a brief review of the research that validates the effectiveness of the relevant practices. Finally, the successful staff development programs of three school districts illustrate how theory is transferred into practice.

Table 1 Summary of Research on Effective Inservice Practices

Dimension	*Effective Practice*	*Basis*
A. Teacher Objectives		
1. Target Competencies instructional methods validated by research.	Teachers should use experiments	Basic skills
2. Operationalization	Inservice program should have operationally stated objectives for teacher behavior.	Implementation research
3. Complexity	If the skills to be learned are complex, introduce them into the teacher's repertoire gradually	Implementation research; inservice research
4. Expected level of performance	Teachers should be told specifically how much to use particular instructional behaviors.	Basic skills experiments; implementation research
B. Student Objectives		
5. Target Objectives	Inservice program should have as its ultimate goal improved student performance.	Basic skills experiments
6. Expected level of achievement	Teachers should be helped to believe that students' academic performance can be improved	Basic skills experiments; teacher expectations research

C. Delivery System

7.	Readiness Activities	Hold meetings that deal with teachers' concerns about the inservice program and that build consensus to participate in it.	Implementation research
8.	Instructional process	Teachers should be given manuals describing the methods covered in the inservice program; should discuss the methods in group meetings with a trainer; and should receive observation and feedback on their skill performance.	Basic skills experiments; inservice research
9.	Maintenance and monitoring	Inservice program should have followup component to maintain and monitor gains made on initial training.	Implementation research
10.	Training Site	Inservice program should use the teacher's own classroom as a training site at least part of the time.	Basic skills experiments; inservice research
11.	Trainers	The trainer should have credibility in the eyes of teachers.	Inservice research
12.	Scheduling	Schedule inservice sessions at times that do not interfere with teachers' other obligations.	Inservice research

D. Organization Context

13.	Purpose for participation	Inservice program should focus on school improvement rather than on personal professional development.	Inservice research
14.	Inservice cohorts	Inservice program should provide activities that allow teachers to work with and learn from each other.	Survey research
15.	Concurrent organizational changes	Principal should participate in and support the teachers' inservice activities.	Implementation research; research on principals' behavior

16.	Other inservice activities	None identified	

E. Governance

17.	Governance structure	None identified	
18.	Teacher Participation in governance	Teachers should have the opportunity to help plan the inservice program.	Survey
19.	Recruitment of participants	Participation should be mandatory in order to bring about schoolwide improvement.	Inservice research
20.	Incentives	Provide incentives like released time, expenses, college or district credits, approval by school principal.	Survey research; implementation research
21.	Sanctions	None identified	
22.	Costs	None identified	

F. Selection and Evaluation

23.	Policy	Inservice program should be selected because of its demonstrated effectiveness in improving students' academic performance.	Basic skills experiments
24.	Needs assessment	Inservice program should be targeted to areas of student performance demonstrated to be in need of improvement.	
25.	Relevance to participants	Content of the inservice should be relevant to the teacher's classroom situation.	Survey
26.	Measurement of teacher competence	Teachers' classroom performance should be assessed to determine their implementation of inservice content.	

27.	Measurement of student objectives	Inservice program effectiveness should be assessed by student performance on relevant measures and in such a way that teachers do not feel threatened.	Research on achievement testing

Notes

1. In most cases the effective practices listed are a direct statement of a finding from one or more research studies. In a few cases the effective practice is a reasonable inference from research findings.

2. The types of research listed in the third column are as follows:

   Basic skills experiments. These are the four inservice experiments (see Appendix B) by Anderson and others; Gage and others; Stallings; and Good and Grouws.

   Implementation research. These are studies, mostly descriptive and correlational, in which the criterion was how well a curriculum or instructional method was implemented in a natural school setting.

   Inservice research. These are experiments in which effects of different inservice practices on teacher competence were assessed.

   Survey research. These are descriptive studies of teacher preferences and attitudes concerning particular inservice practices.

   Other research. Some studies relating to teacher expectations, school principals, and achievement tests are relevant to several of the inservice dimensions.

A Teacher Objectives

Inservice education is usually defined as a change in teacher ability brought about by new learning. Joyce and his colleagues (1976) defined inservice education as "formal and informal provisions for the improvement of educators as people, educated persons, and professionals, as well as in terms of the competence to carry out their assigned roles" (P.6). Inservice education attempts to improve teacher capacity in three broad areas: Knowledge, attitudes, and skills. Thus, we define inservice teacher education as efforts to improve teachers' capacity to function as effective professionals by having them learn new knowledge, attitudes, or skills. These outcomes constitute the teacher objectives of an inservice activity.

1 Target Competencies

Each of the four inservice experiments described in Appendix B emphasized teaching skills rather than knowledge and attitudes. These experiments sought to determine whether specific teaching behaviors can be linked to growth in students' basic skills achievement. It seems desirable, whenever possible, to select inservice programs whose content can be validated in this way, namely, by demonstrating the links between the teaching behaviors emphasized in the program and the criterion of student performance.

Roehler and Duffy (1981) suggested that the teaching skills validated in the four inservice experiments generally can be classified into two types: Monitoring behavior, in which teachers ask pupils to perform a desired basic skill; and reactive-corrective behavior, in which students receive help when they fail to make a desired response. These two instructional strategies presumably are effective because they ensure a high engagement rate of students in academic tasks.

Two studies used an academic learning time (ALT) model as the teacher objectives of an inservice program. In a study by Helms (described by Rouk, 1981) the five key instructional variables were allocated time, engagement rate, student engaged time, students' prior learning, and instructional overlap, that is, the match between instructional content and achievement test content. The last two of Helms' instructional variables are of particular interest because they require a change in teachers' curriculum content rather than in their instructional style. Hutchins' study (described by Saily, 1981) also tested the effectiveness of an inservice workshop for increasing ALT in schools.

Although evidence on teachers' ability and willingness to change their curriculum content is not yet available from Helms' and Hutchins' research, a study by Porter (1981) indicates that teachers are quite willing to change their curriculum content in response to such external influences as standardized tests, principals, other teachers, and parents.

The four inservice experiments measured teachers' use of the instructional skills that formed the target competencies. We should stay open to the possibility that other changes might result from inservice programs. For example, an inservice program may affect teachers' self-concept or beliefs about education, even through those effects were not part of the formal objectives of the program. These effects on teachers may be immediate (side-effects) or may show up months or even years after training (long-term).

2 Operationalization

The research on curriculum implementation reviewed by Fullan and Pomfret (1977) and by Hall and Loucks (1980) indicates that the explicitness—or ability to be expressed in operational terms—of a curriculum or of inservice content has an effect on its implementation. Hall and Loucks concluded that "research and experience have shown that unclear expectations are one way to guarantee nonimplementation. Teachers appreciate clear objectives—they need to know what they are expected to do and how their roles are to change" (p.16).

It is difficult to imagine how a teacher can acquire new instructional skills unless the skills are clearly made operational or explicit. Thus one criterion of an effective inservice program is likely to be the extent to which its content is clearly operationalized. Unfortunately, Ogletree and Allen (1974) found that a majority of their sample of elementary teachers believed that the objectives of their inservice meetings were not clearly defined. A characteristic of the four inservice experiments is that the teaching skills are stated at a relatively low inference level and are easily observable in a model teacher's performance.

3 Complexity

The complexity of a new curriculum or inservice program has an effect on its implementation. The complexity of teacher objectives in an inservice activity is probably a function of several factors, including the number of skills to be learned, whether the skills already exist to some degree in the teacher's repertoire, and the extent to which the skills must be adapted to classroom conditions. Hall and Loucks (1980) recommend that "when the innovation is complex...major components should be phased in one or a few at a time" (P.18). Gerstein, Carnine, and Williams (1982) found that teachers in their sample needed to learn the skills of a complex direct instruction model in phases—several skills in each phase—over a relatively long period of time.

These findings suggest that if complex teacher objectives are delivered to teachers in just a few sessions, the inservice activity will have little effect on teachers' instructional behavior, and subsequently it will have little effect on students' academic achievement.

4 Expected Level of Performance

This dimension of teacher objectives is related to dimension 2 (operationalization), which refers to the explicitness of the teacher objectives. Expected level of performance refers to the specificity of criteria for determining whether the objectives have been met.

In skills-based inservice programs, teachers are expected to increase or decrease their use of particular instructional behaviors. The direction, but not the degree, of change is specified in most programs. An important feature of the four inservice experiments is that they suggest specific levels of use for some instructional behaviors. For instance, one of the recommendation in the behaviors by Gage and colleagues is that "teachers should avoid calling on volunteers more than 10 or 15 percent of the time during question-and-answer sessions" (1978, Appendix A, p.4) In their study, Good and Grouws (1979) recommend that the teacher spend the first twenty minutes of a Monday math period conducting a review of skills and concepts covered during the previous week.

B Student Objectives

Inservice activities have objectives at two levels. The immediate objective is to bring about an increase in teacher competence. The long-range objective is to bring about improvements in student performance as a result of the increase in teacher competence. In this section we discuss dimensions related to these long-term objectives of inservice education.

We are aware that the connections between improved teacher competence and improved student performance are complex. Sometimes, the connections may be explicit and experimentally validated, as in the case of the training programs used in the four inservice experiments. We suspect, however, that in many inservice activities the connections between teacher objectives and student performance gains are vague and unverified. Weick (1976), among others, has commented on the prevalence of loose coupling is that staff developers often design inservice activities without communicating with other school educators who are responsible for monitoring and improving student performance.

5 Target Objectives

Educators are well aware that in recent years public criticism of the schools has focused on the failure of many students to acquire basic skills in reading and math. A report by Schalock (1977) on the status of professional development in Oregon stated that there "is an increasing demand for schools in Oregon, as there is throughout the nation, to provide better preparation in the basic skills of reading, writing, and computation" (P.1). We might expect then, that a high proportion of inservice activities are concerned with basic skills objectives. However, the only study we could locate with pertinent data indicated that just the opposite is true. In this study, Sullivan (1981) found that only 10 percent of the New York City Schools inservice programs were related to reading and math instruction.

Research on teacher preferences and values suggests that basic skills development would not be a high inservice priority for teachers. Schurr and his colleagues (1980) discovered that teachers prefer inservice topics that concern student motivation and attitudes. Research by Prowat and Anderson (1981) indicated that elementary teachers consider their most important task to be attending to students' affective needs: When teachers were asked about their priorities, they "made twice as many statements about things they did to promote affective growth (for example,getting students to interact positively or feel good about themselves) as compared to cognitive growth" (P.1). Similarly, a study by Harootunian and Yarger (1981) suggested that most teachers judge their success by the degree to which they involve their students affectively in instruction. These results indicate that, when given a choice, teachers would opt for inservice objectives having an affective theme rather than a basic skills emphasis.

Target objectives for students are a very important dimension of inservice education. Cawelti (1981) observed that support for inservice education ultimately rests on its demonstrated connection to "objective productivity criteria," such as basic skills achievement. Critics of the federally funded Teacher Centers claimed that such centers should not be supported because they served the needs of teachers rather than the needs of students.

Some inservice programs may seek to train teachers with the expectation that change in teacher competence will produce direct changes in student performance. There may be additional expectations that these changes in student performance will lead to other changes in students, either concurrently or over a longer period. For example, some educators believe that if student self-concept is improved (direct effect), there will be subsequent improvement in student academic achievement (side effect). Another example is provided by inservice programs designed to help teachers acquire skills for reducing student discipline problems in the classroom. It is conceivable that reduction of student discipline problems (direct effect) will lead immediately to more instructional time on task (side effect).

6 Expected Level of Achievement

Brophy and Good (1974) provide ample research evidence that educators have expectations about students' achievement potential. We know little, however, about the relationship between educator expectations for student achievement and educator support for inservice programs as a response to these expectations. It may be that decline in test scores over time within a school district is a more effective trigger for initiating a basic skills program than is the perception that students are performing below expectations.

In fact, there is some reason to believe that educators adjust expectations to match the realities of student achievement. For instance, in 1976 the California legislature enacted minimal competency requirements for high school graduation but allowed each district to make up its own test and set its own standards. Savage (1982) reported that "fewer than one percent of high school students were denied a diploma...because of the test" (P.251).

C Delivery System

The delivery system of staff development programs refers to the process used to achieve teacher-level objectives, that is, gains in teachers' knowledge, skills, and attitudes. Traditional delivery systems include presentations by experts during a school district's inservice days; university coursework, which typically is in a lecture/demonstration/discussion format; and hands-on workshops. Another characteristic of traditional inservice delivery systems is that they usually are brief, "one-shot" experiences.

Now, however, educators are increasingly advocating multistage, longterm delivery systems that include both training and implementation strategies. The model developed by Pankratz and Martray (1981) proposes an eight-stage inservice/school improvement program that includes awareness building, skill training, implementation assistance, and monitoring and maintenance. In this section we review evidence that supports the effectiveness of these components in an inservice delivery system.

7 Readiness Activities

We use the term readiness activities to refer to the inservice experiences provided to teachers and administrators prior to the skill-training phase of a delivery system. Loucks and Pratt (1979) find evidence in their review of research suggesting that readiness activities have an important effect on how well inservice training is implemented.

The literature on inservice education suggests several activities that should be included in the readiness phase. For example, Pankratz and Martray (1981) identify the following activities as being helpful: developing an awareness of need among formal and informal school leaders, obtaining these leaders' agreement on a delivery system, and using exploratory workshops to provide information and to develop consensus.

Miller (1981) argues that teacher acceptance of personal responsibility for student achievement is an important component of an effective school improvement program. This claim is supported by Berman and McLaughlin (1978) who found that teachers' beliefs about whether they could help students were correlated with the degree of new program implementation. Readiness activities might be conducted to help teachers raise their expectations of students and to improve teacher attitudes toward their own instructional efficacy.

The concerns-based approach to curriculum change developed by Loucks and Pratt (1979) also suggests several readiness activities that might be incorporated into an inservice delivery system. Their research indicated that teachers have three types of concerns prior to becoming involved in inservice training and curriculum implementation: absence of concern, concern to know more about the program, and concern about how its use will affect them. Loucks and Pratt describe a preinservice session that they developed to help teachers deal with the first two concerns in a particular curriculum implementation project.

8 Instructional Process

Instructional process refers to the methods used by inservice staff to train teachers in knowledge and skills or to modify their attitudes. Appendix B summarizes the instructional processes used in the four inservice experiments.

In our examination of commonalities in the four inservice experiments, we found that each of the inservice programs involved at least two meetings. (The "minimal" group in Gage's study did not attend any meetings, resulting in lower end-of-year achievement scores relative to the "maximal" group.) Another common feature across the studies was the use of brief manuals to describe the desired behaviors.

Teacher behavior was observed and critiqued in two of the four inservice experiments. Teachers in Stalling's experiment were observed in their classrooms and given both a qualitative and a quantitative summary of the results. Gage's "maximal" group of teachers was observed in role-playing exercises during meetings. Teacher behavior was observed in one of Anderson's trained groups, but the summaries of observations were not shared with the teachers. The ongoing research of Helms and of Hutchins includes evaluation of observation and feedback components of inservice programs. The Lawrence and Harrison (1980) meta-analysis revealed that successful inservice programs tend to include a sequence in which participants try out new behaviors in their classrooms or in simulations and then receive feedback from a skilled person.

Overall, research suggests that teacher productivity in basic skills instruction can be increased by using a relatively simple instructional process. It should be noted, though, that none of the four inservice experiments extended over a period of more than a single school year. Also, the programs were not successful for all teachers. Instructional processes not used in the four experiments may produce more sustained effects, and effects for more teachers, than those used in the four inservice experiments. For example, the coaching procedure described by Joyce and Showers (1982) may significantly enhance the effectiveness of training manuals and meetings by promoting transfer of the instructional principles to the teacher trainee's particular classroom situation. We could locate no data, however, on how frequently coaching and related processes occur in practice.

9 Maintenance and Monitoring

Maintenance refers to the use of followup measures to help teachers preserve or increase gains made in initial training. Monitoring refers to the use of procedures for making continued observation of teachers' adherence to desired instructional strategies or of student performance.

Changes in teacher behavior as a result of training tend to revert to baseline levels over a certain period. Johnson and Sloat (1980) found reversions to baseline rate twelve months after completion of training. It appears, then, that monitoring and maintenance procedures are desirable if teacher productivity gains are to be preserved over a number of school years.

An important element of the four inservice experiments is that the project staffs maintained contact with the teachers over a duration of months by spacing training sessions and by collecting classroom data on the teacher behavior and test data on student achievement. The continued observations are like a monitoring process and thus may have cued teachers to reinstate desired instructional behaviors.

In Gage's experiment, a maintenance intervention was used several months after the initial five-week training period. Both the maximal and the minimal group received a refresher training manual. In addition, the teachers in the maximal group were videotaped and given feedback on their implementation of instructional principles.

One of the conclusions Fullan and Pomfret (1977) reached in their review of research was that "intensive inservice training (as distinct from single workshops or preservice training) is an important strategy for implementation" (p.373). This particular conclusion was based primarily on the Rand studies of educational change conducted by Berman and McLaughlin (1978). It seems reasonable that "one-shot" inservice education will have less effect on teacher productivity than continuous inservice education that includes monitoring and maintenance procedures.

Maintenance and monitoring activities do not appear to be features of current inservice practice. In the survey conducted by Betz and colleagues (1978), less than 20 percent of the teachers reported that their inservice meetings included followup activities. In an earlier survey, Ogletree and Allen (1974) found that a majority of urban teachers reported no followup or evaluation of their inservice meetings.

10 Training Site

We could locate no empirical data concerning teacher preference for training sites. The teachers' own classrooms were used as "training" sites in the four inservice experiments in that the teachers' behavior was observed in their classrooms to assess implementation of the desired instructional behaviors. In Stallings' study, these observational data were also used as personal feedback to the participating teachers.

In their meta-analysis, Lawrence and Harrison (1980) found that inservice programs tended to be more effective when conducted at the school site, but this generalization applies only to inservice programs that emphasized affective or skill performance objectives.

11 Trainers

Each of the four inservice experiments required one or more inservice trainers. Their roles generally did not require close, sustained involvement with the teachers. It is not known whether individual differences between inservice trainers would influence the effectiveness of the inservice programs used in these experiments.

Teachers surveyed by Betz and colleagues (1978) reported that they learned the most from other teachers. However, their ratings of college and university personnel and professional consultants were nearly as high. McDonald (1980) reviewed a series of British experiments on teacher induction programs and concluded that the most successful ones were those that made available to the beginning teacher an experienced teacher who could serve as a monitor, model, and counselor. McDonald questioned whether it was necessary for an experienced teacher to perform these roles, or whether others, such as a principal or university supervisor, could perform them.

12 Scheduling

We see at least three issues related to the scheduling of inservice activities: time of day or week for holding an inservice session, spacing of inservice sessions, and the time frame over which a particular inservice program is implemented.

With respect to the first issue, Betz and colleagues (1978) found that the teachers in their sample generally preferred inservice education to be scheduled during school hours. In practice, though, over half of the sample reported attending some inservice activities before and after school, and a fourth of the sample reported attending weekend inservice activities. The training sessions in the four inservice experiments were held at various times during the day or week, except for the collection of classroom observation data and student achievement tests.

The results of the Harrison and Lawrence (1980) meta-analysis do not support the teacher preferences expressed in Betz's survey. Lawrence and Harrison found that effective inservice programs tended to be scheduled during the evenings and summers, when the activities did not compete with other professional duties of teachers. Inservice programs scheduled during work hours were considerably less successful in achieving objectives.

Sessions of a typical inservice program can be held together—for example, an intensive weekend workshop—or they can be spaced over a longer period. We could locate no research on teacher preferences for massed or spaced sessions. A possible advantage of spacing inservice sessions is that it would provide sustained contact between teachers and trainers, allow for spaced practice of new skills, and allow more time for teacher concerns to surface and be addressed.

The third scheduling issue is the time frame over which a particular inservice program is to be implemented. Loucks and Pratt (1979) emphasized the need for a substantial time frame: "Research indicates that three to five years are necessary to implement an innovation that is significantly different from current practice" (p.213). Fullan and Pomfret (1977) also concluded that implementation of innovations, with concurrent inservice support, requires a long-term perspective.

The time frame used in three of the four inservice experiments was one school year. The experiment conducted by Good and Grouws extended over a four-month period. The discrepancy between the time frame in these experiments and those time frames recommended by curriculum implementation researchers may reflect differences of purpose. The primary purpose of the four experiments was to demonstrate the effects of inservice training on student achievement. In contrast, curriculum implementation is concerned with the institutionalization of an innovation as part of a school improvement effort. This purpose may well require a longer period of time to accommodate readiness activities, train all staff, and monitor and maintain training effects.

D Organizational Context

Inservice education is fundamentally a learning experience that occurs for individual teachers. It is also the case that teachers are members of school organizations. Characteristics of these organizations may well influence the delivery of inservice education programs to teachers. The same characteristics may also influence the effects of the programs on teachers and their students. In this section we consider three characteristics of school organizations that are likely to influence inservice program effectiveness.

13 Purpose for Participation

This dimension was suggested by the discussion in Joyce and colleagues (1976) of the "model system" in inservice education. The model system refers to the organizational context in which inservice education occurs. Joyce and his colleagues identify five such contexts: the job-embedded mode (school committee work), the job-related mode (school district workshops outside of regular school hours), the credential-oriented mode (university certification courses), the mode of professional organization-related work (NEA workshops), and the self-directed mode (sabbatical leaves).

We prefer to think of these modes as representing different purposes for inservice education. Therefore, we distinguish four such purposes: first, inservice for personal professional development, which corresponds to the self-directed mode and perhaps to the professional organization mode; second, inservice for credentialling, which corresponds to the credential-

oriented mode; third, inservice for the purpose of being inducted into the profession; and fourth, inservice for school improvement, which corresponds to the job-embedded and job-related modes.

The first three purposes relate to the development of the individual teacher. Inservice for school improvement, though, gives priority to the school organization. The teachers' personal needs may be taken into account, but their role as members of the school organization is critical to this form of inservice education. Campbell (1981) developed two separate models of inservice education education based on this distinction between the needs of the school system and the needs of the teacher. Miller and Wolf (1979) developed a cyclical staff development/school change model that reflects these two purposes of teacher education.

The four inservice experiments all focused on the individual teacher in the classroom. Teachers volunteered for the inservice programs; they were not recruited because they were members of a particular school staff. Also, the building principals and district curriculum specialists were not directly involved in the program, as they might have been if the program had been conducted for the purpose of school improvement.

Hutchins' ongoing study, described by Saily (1981), is testing basic skills programs for the purpose of school improvement. The program covers content similar to that covered in the four inservice experiments, but there are several important contextual differences. The most critical difference is in who receives the training: "The workshop series is generally conducted for a school district or group of schools within a district. Each participating school sends to the workshop a team of the principal and two or three teachers; a central office staff member is also involved" (p.11). The workshops also cover training standardized achievement testing to help educators increase the content validity of tests administered in their districts.

The Lawrence and Harrison (1980) meta-analysis indicated that the more effective inservice programs were designed as a collective effort of a school staff. Also, the more effective programs had shared goals rather than individual teacher goals. These results suggest that inservice for school improvement is generally more effective than inservice for personal professional development.

14 Inservice Cohorts

The available research on this dimension indicates that teachers have a strong preference for working with other teachers in their inservice activities rather than working by themselves. Lawrence and his colleagues (1974) concluded from their research review that inservice activities produced more positive effects on teachers when they provided mutual assistance in an inservice program than when they worked alone. Holly (1982) found in her survey of 110 teachers that they most preferred inservice activities that allowed them to work with other teachers: "Teachers described their colleagues as valuable sources of practical ideas and information, helpful advisors on professional problems, the most useful evaluators of teaching skills, and understanding allies" (p.418). Similarly, Ngaiyaye and Hanley (1978) surveyed 228 teachers and found that the teachers preferred inservice meetings organized for colleagues with similar teaching responsibilities.

We consider it worthwhile to distinguish at least three aspects of teacher grouping for an inservice activity: individually bases versus group-based instruction, homogeneous versus heterogeneous grouping with respect to teaching responsibilities, and same-school versus different-school grouping. However, we could locate no evidence as to the relative effectiveness of variations in these groupings.

The four inservice experiments used a combination of individually based instruction (study of manuals) and group-based instruction(inservice meetings). Also, the four experiments included teachers at the same grade level. This feature of inservice group composition may be particularly relevant because it helps to increase the pertinence of the inservice activity to each teacher's classroom situation.

15 Concurrent Organizational Changes

As indicated above, one major purpose of inservice education is to bring about school improvement. If an inservice activity is used for this purpose, it would be informative to learn whether the activity is supported by other changes in the school system of which the teacher is a member.

The building principal is probably the most influential symbol of school organization for teachers. Loucks and Pratt (1979) concluded from their research that "what the principal does is critical to the success of an implementation effort" (p.215). These critical role behaviors of the principal are commonly referred to as "instructional leadership."

Leithwood and Montgomery (1982) reviewed the research on the role of the principal in school improvement and found that the more effective principals were more likely to participate in teachers' inservice activities. Participation included attending all or at least the early inservice sessions for teachers.

Another type of organizational change relevant to inservice education is curriculum change. Inservice education is sometimes used to support implementation of a new curriculum. In turn, the new curriculum may include features that facilitate the teacher and student objectives of the inservice program. Examples of such features include teacher manuals that contain lesson plans based on direct instruction principles, curriculum-referenced tests, and learning activities that ensure high student success rate. We could locate no research on whether inservice is more or less effective when it accompanies curriculum revision.

16 Other Inservice Activities

The effects of a particular inservice program are possibly dependent on other inservice programs that the teacher experiences either concurrently or at some point in time. These other programs may reinforce and build upon the objectives of a particular program by diffusing the teacher's attention across disconnected priority goals.

Research on how teachers' inservice experiences articulate with each other across a specified period is scarce. A few studies have addressed the related question of the quantity of inservice that teachers receive. Arends (1983) studied beginning high school teachers over a three-year period. His sample participated in a mean number of 10.5 inservice activities during the interval, for an average of 3.5 activities per year. The mean total number of inservice hours was 291 or 97 hours per year. In contrast, Schalock (1977) surveyed 450 teachers and found that they engaged in a mean number of 1.5 activities in the course of a year.

Two differences in the methods used by Arends and Schalock may explain their disparate estimates of inservice quantity. Arends used interviews and studied only beginning teachers. Schalock used questionnaires and studied teachers with a much wider range of teaching experience.

An interesting finding in Arends' study was a correlation of .67 between (a) the principal's rating of a teacher's competence at the end of the teacher's first inservice year and (b) the teacher's total number of inservice hours over the three-year period. This finding may mean that participation in many inservice activities leads to improved teacher effectiveness, but an equally plausible interpretation is that a teacher's high involvement in inservice activities is seen by the principal as a sign of competence.

E Governance

Governance involves a number of policy and management decisions that may influence the effects of inservice education on teachers and their students. Governance issues have been at the forefront of dialogue on inservice education in recent years. For example, the federally funded Teacher Centers were established on the premise that inservice education would be more effective if teachers controlled its design and governance. Below, we review the available research concerning various dimensions of inservice governance. The four inservice experiments are not informative about these dimensions because the decision to institute the experimental programs primarily reflected the researchers' initiatives rather than school system initiatives.

17 Governance Structure

This dimension is meant to represent the individual or group having responsibility for making key inservice policy decisions concerning the selection of inservice objectives and activities, incentives and sanctions, and the allocation of resources. Some school districts have governing boards to make these decisions. In other settings these decisions may be left to the building or district staff development specialist.

Inservice programs may be associated with several levels of governance. In some cases, an office of a state department of education may make the decision to mandate a certain type of training at the district level. In turn, a governance board at the school district level may assume the responsibility for the way this training will be designed and offered to district teachers. We could identify no research on whether variations in governance structures have an influence on the effectiveness programs.

18 Teacher Participation in Governance

As might be expected, surveys (Betz and others 1978, Holly 1982, Schurr and others 1980) typically find that teachers desire input into the planning of inservice programs. Inservice leaders such as Gehrke and Parker (1981)and Johnson and Yeakey (1977) also advocate collaborative

planning among teachers and administrators to ensure successful implementation of an inservice program. Three prominent educators, Ryor, Shanker, and Sandefur (1979), concluded that "inservice programs imposed from the top down are doomed to failure" (p.15). The Lawrence and Harrison (1980) meta-analysis revealed that inservice programs in which teachers chose at least some of the goals and activities were more effective than entirely preplanned programs for increasing teacher competence.

19 Recruitment of Participants

Participation in an inservice activity can be voluntary or required. There probably are degrees of participation between these two extremes. For instance, administrators may stop short of requiring participation but may use strong incentives or sanctions to ensure high participation rates. The critical element, then, is probably not whether the inservice activity is voluntary or mandatory but whether teachers feel coerced into participating. Even if a particular activity is required, teachers may not react negatively if they wish to participate.

The four inservice experiments involved volunteer samples of teachers. Voluntary participation seems reasonable if the purpose of the activity is to conduct a researcher-controlled experiment, as in the case of the four experiments, or to encourage the professional development of individual teachers. When the inservice education is used for the purpose of school improvement, however, mandatory participation may be more effective. School improvement may require the staff to make individual preferences and needs secondary to school goals.

We could locate no research data about the extent to which current inservice activities are voluntary or required.

One related finding in the Lawrence and Harrison (1980) meta-analysis was that mandatory versus voluntary participation of teachers did not predict inservice program effectiveness.

20 Incentives

A reasonable hypothesis is that incentives influence teachers' willingness to participate in as inservice activity and their satisfaction with the experience. We could not locate empirical tests of this hypothesis, however. Some descriptive data about inservice incentives were collected in the survey of teachers carried out by Betz and colleagues (1978). Teachers reported that "the most common and also the most preferred types of compensation included released time, expenses, credit for certificate level, and college credit" (p.492). The Rand studies by Berman and McLaughlin (1978) revealed that teachers were unlikely to continue implementing a new curriculum or method without approval of the principal. The reports of the four inservice experiments do not specify what types of incentives , if any, were given to participating teachers.

21 Sanctions

In the discussion of participant recruitment (dimension 19), reference was made to the possible use of coercion to secure teacher participation in an inservice activity. The dimension of sanctions refers to the use of threats to secure teachers' agreement to participate in an activity, or to punish

them for nonparticipation. An example of such a tactic is to require remedial supervision as a condition of continued employment. Another example is the nonrenewal of a teachers' certificate if a minimum number of credits are not earned within a given time limit. No research about the use of sanctions in staff development programs could be located.

22 Costs

There is surprisingly little information in the literature about the costs of particular inservice programs. A survey of Oregon School districts several years ago (Schalock 1977) found that typically 3 to 5 percent of district budgets was allocated to inservice education. It is not known how much teachers pay on their own for inservice programs and whether such expenses affect how much teachers benefit from the programs.

F Selection and Evaluation

The evaluation of inservice program is not a well-developed field. Lawrence and Harrison (1980) began their meta-analysis of the inservice literature with a review of approximately 6,000 abstracts and references. Only 150 of these documents reported quantitative data, and only 59 percent of those contained sufficient data for inclusion in the meta-analysis. This suggests that systematic evaluation of inservice program is the exception rather than the rule. One of the few efforts to conceptualize the parameters and purposes of inservice evaluation was made by Gall and others (1976). Gall and his colleagues sought to conceptualize the levels of impact that might result from an inservice program. Four such levels were proposed:

Level I Implementing the inservice program is conducted. A possible indicator of Level I impact is the number of teachers who choose to participate in the program and the number of teachers who complete it.

Level II Teacher improvement. This type of impact refers to the effects of the program on teacher competence.

Level III Change in student performance. many inservice programs have the goal of changing teacher behavior (Level II).

Level IV Changes in the environment. Levels II and III of program impact might spread to other contexts. For instance, teachers who learn about a new instructional technique in an inservice program might informally teach it to their colleagues.

Each of these levels of impact can be the object of evaluation. We have included Levels II and III as the dimensions 26 and 27, respectively, because they are the most direct outcomes of inservice programs. Dimensions 23,24, and 25 relate to the quality of the process by which a program is selected or developed for presentation to teachers.

23 Policy

This dimension refers to the rationale and evidence that decision-makers use to justify the use of inservice activities to achieve educational goals. Inservice education is just one option that can be used to implement policy. For example, if the goal is to improve students' basic skills achievement, administrators might consider these other options: reducing class size, hiring more teacher aides, or issuing directives to teachers to spend more time on basic skills instruction. Inservice education must compete with these options in the policy-making process.

A decision-maker's rationale for selecting the type of inservice activities used in the four inservice experiments probably would be that such activities are of demonstrated effectiveness in improving student achievement. There is evidence, though, that decision-makers may not be receptive to such research data on inservice effectiveness. Schalock (1977) found widespread concern among Oregon educators about the effectiveness of inservice programs as a method of improving educational practice. The problem is compounded by the fact that in some settings the work of staff development specialists is only loosely coupled to policy-making of school administrators. Vacca and others (1981) found that "no one identifying primarily with staff development claimed to experience intimate involvement in the decision-making process. Staff developers perceive themselves as middle managers with limited access and little power" (p.51).

The most noteworthy feature of the four inservice experiments in this area is that teacher objectives are derived directly from correlational research linking teachers' instructional behaviors to student gains in basic skills achievement. This "rational" approach may be the exception rather than the rule. In their study of curriculum implementation, Berman and McLaughlin (1978) found that few school districts in their sample conducted a rational search for better ways to educate students. Edwards (1981), too, criticized staff development programs for being "a conglomeration of activities determined by decision making criteria such as cost or availability or strong advertising" (p.2).

24 Needs Assessment

The training programs in the four inservice experiments were not selected as a result of formal needs assessment process. The purpose of these experiments was to validate through controlled conditions the effectiveness of particular training programs rather than to respond to identified needs of school districts. In practice, though, school districts may initiate inservice programs for reasons other than demonstrated effectiveness.

The literature suggests that a formal needs assessment is the recommended process for identifying inservice objectives. Naumann-Etienne and Todd (1976) and Powell (1980) have described models for developing a comprehensive inservice program for a school system. Both models rely heavily on such needs assessment techniques as site visitations to diagnose system needs, surveys of teacher concerns, and surveys of teacher priorities. Nelson (1981) reported that the Montgomery County School District in Maryland initiated an inservice program to support an instructional renewal of training needs for the district's teachers.

We were unable to identify any research on the prevalence of formal needs assessment to identify inservice objectives. It may be that inservice objectives and activities are selected by a much more informal, opportunistic process. A particular administrator may initiate an inservice program because of its merits, because he or she heard about its success in another district, or because the school board identified a problem for which an inservice activity seemed an appropriate solution.

25 Relevance to Participants

Researchers have found that teachers generally evaluate the effectiveness of an inservice program by how relevant its content is to their particular classroom situation. Holly (1982) interviewed 100 K-12 teachers and concluded that "the single most important factor determining the value teachers placed on an inservice education activity was its personal relevance" (p.418). Similarly, Vacca and her colleagues (1981) found that teachers' major criterion in rating the effectiveness of staff development personnel was the relevancy of their message. Teachers preferred staff development specialists who gave them "ideas, strategies, and materials that relate directly to their own classrooms" (p.51). It is disappointing, then, that the elementary teachers surveyed by Ogletree and Allen (1974) felt that their inservice meetings generally were irrelevant to their professional work.

Joyce and others (1976) reported that the teachers interviewed in the ISTE Concepts Project "were much less specific and clear about substance and process than any other aspect of the structure of ISTE" (p.23). The investigators concluded that "the interviews, position papers, and literature all reveal an agreement that much of ISTE contains substance which is irrelevant to the needs of classroom teachers" (p.23).

The training provided in the four inservice experiments was probably implemented in part because it was quite relevant to the classroom situations of the participating teachers. The instructional principles were derived from previous correlational research based on observations of teachers similar to those who participated in the experiments. In fact, in Stalling's experiment some of the teachers had also participated in the correlational study. Thus, the instructional principles were directly relevant to the teachers' classroom situations. The teaching behaviors reflected in the principles were already present to some degree in most teachers' repertoires. Inservice training consisted primarily of having teachers do either more or less of what they already were doing in their classrooms and of sequencing their activities appropriately.

The training in the four experiments was also relevant in that all the participating teachers in a particular experiment were at the same grade level. Thus, a question or problem raised by a teacher at a training meeting probably would be relevant to the other teachers as well.

26 Measurement of Teacher Competence

A major justification for inservice programs is that they produce desirable changes in teacher competence. Our review of the literature revealed that this claim is rarely tested. Evaluation involving objective measurement of teacher competence is seldom included as a component of inservice programs for teachers. Measurement procedures can range from administering questionnaires and surveys to observing teachers' classroom behavior.

The four inservice experiments all involved direct observation of the teachers' classroom behavior before and after the inservice training process. The observation focused on the teachers' use of instructional behaviors that researchers had found to correlate with student achievement gains. The purpose of collecting the observational data was to determine whether the experimental inservice program was more effective than a no-training condition.

Measurement of gains in teacher competence requires resource expenditures by the agency sponsoring the inservice program. We could identify no research on whether policy-makers find utility in measurement data on teacher competence, nor could we locate any studies on the relative benefits of collecting teacher competence data and student achievement data for evaluating inservice projects.

27 Measurement of Student Objectives

The technology to measure most student objectives of inservice programs is available to educators. Whether administrators choose to measure the objectives, and for what purpose, are matters of policy. In the four inservice experiments, the student objectives were basic skills gained in reading and math. These skills were measured in each study by standardized achievement tests. The test data were used to assess the effects of the inservice programs that comprised the experimental treatments in these studies. Reinstein (1976) noted other useful purposes that could be served by such achievement tests: they can help to determine allocations of resources to alleviate weakness in instructional programs and to assess whether students are acquiring minimum competencies as they progress through school.

Although standardized achievement tests are useful in certain circumstances, they are also problematic. Saily (1981) referred to a recent study at the Institute for Research on Teaching at Michigan State University. This study indicated that 30 to 40 percent of the items in standardized tests are not covered by commercial textbooks at the same grade level. Because teachers rely heavily on these textbooks to determine their classroom instructional content, there is probably a weak match between what teachers teach and what standardized tests measure. Thus, the test results may have low validity for measuring the objectives of some inservice programs. If teachers attempt to "teach to the test," they may need to deviate substantially from their textbooks and devote extra effort to improving the match between their instructional content and the test content. This extra effort may arouse resentment in teachers and resistance to school system efforts to promote basic skills achievement.

Another potential problem of standardized tests is that they may be used to evaluate teachers and to make them the prime targets of accountability for student progress. Edwards (1981) reported that "apprehensiveness of teachers about the process of evaluation, their distrust of the accountability movement, and their fearfulness of becoming scapegoats for the failure of innovations" (p. 1) is widespread.

Case Studies

Educational administrators and teachers alike are well aware of the difficulties involved in transferring theory into practice, but generally they recognize the essential relationship between the two. Most educators who achieve success in their efforts to improve the quality of their schools do so because they possess among their talents the ability to think carefully about potential difficulties, plan for them, and eliminate the problems before they occur. This is the central role that theory can play for educators. It can give them the tools and ideas necessary for constructing rational, well-developed procedures, and it can assist them in implementing their plans effectively.

Schools and school districts, because they are made up of individuals, take on the characteristic of those individuals. Thus, each one is unique. Yet, paradoxically, each can also be representative of others. The school district staff development programs described below are meant to demonstrate both roles. These programs might be representative because they are large, medium, or small in size. Also, each of them, like most school districts across the nation, have suffered from budget constraints yet is achieving some measure of success. Still, each is an individual school district with characteristics all its own.

Location of all three programs in one state resulted simply from our need for a convenient means of identifying programs. Appreciation is due the Association of California School Administrators for responding to our request for a list of school districts operating exemplary staff development programs.

As the following descriptions reveal, much thought has gone into the design, implementation, and evaluation of these inservice programs. If anything, the descriptions do not do justice to the complexity of the programs and the energy invested in them.

Dimensions described in the previous section that are related to specific aspects of the programs are not mentioned by name, but they can be easily recognized. Also, although the use of theory probably contributed greatly to the success of each program, that alone was not enough. All the administrators interviewed communicated the qualities of enthusiasm, optimism, patience, and commitment. As we study theory in our attempts to improve the quality of education, perhaps we should pause to consider how these personal qualities can also contribute to our efforts for success.

Whittier Union High School District

Jerry Haines is director of staff development for the Whittier Union High School district in Whittier, California. In this position, he oversees the inservice programs for about 350 teachers from six high schools with a total enrollment of almost 10,000 students. The district offers a variety of inservice topics in specific areas, including programs for teachers of gifted students, curriculum-specific programs, and writing workshops. But the centerpiece of the district's staff development efforts is the "Teacher Power Program" designed by inservice education personnel for the overall purpose of improving teachers' basic teaching skills.

The program combines clinical teaching techniques, elements of Dr. Arthur Costa's "Enabling Behaviors" program, and other inservice methods into four days of workshop activities meant to help teachers in three specific areas. The first area involves analysis of classroom teaching styles and student learning styles. The second component provides teachers with a five-step lesson

design, which concentrates on specific behavioral objectives and on methods for eliciting more active classroom participation from students. The third component seeks to bring about higher levels of questioning by teachers in order to achieve higher levels of thinking on the part of students. Haines believes the program encourages, "Responsive Behaviors on the part of the teacher, clear classroom planning, and a higher level of questioning skills. "All these procedures, Haines says, "build success in students and a more positive atmosphere."

The "positive atmosphere" Haines describes is related to the districtwide objectives of all inservice activities. He believes individual improvement and school improvement are integrally related; in fact, they are inseparable. "We work with the individual," he says, "but we are doing it at such a broad level that it influences the whole school. Your purpose is the total—but you work through individuals."

Program design includes input from a committee of teachers and administrators. The district has three inservice days per year for each school, so some of the inservice activities are planned for those days, though other activities occur after school and on weekends. Substitutes are often used, so teachers can have some flexibility in scheduling. The inservice staff includes two teacher trainers to assist in the delivery of the Teacher Power Program and other inservice offerings. A letter explaining the purpose and scheduling for the programs is sent to all participants. Also, a short orientation meeting is held before the actual workshops begin, and the Myer-Briggs Personality Inventory is administered as part of the readiness activities.

Recognizing the need for consistency between program objectives and evaluation methods, Haines reports that the district redesigned its evaluation procedures so that the criteria for evaluation helped to measure more accurately the attainment of staff development goals. He emphasizes the importance of including staff development in the overall program of teacher evaluation:

> The process of evaluation includes a preassessment and sets up a professional development plan. Within the plan, an inservice is planned or prescribed by an administrator or requested by the teacher for updating skills or getting new kinds of skills, for example, skills related to curriculum content or writing. We assess at the beginning of the year what the teacher's needs are, provide the inservice to meet those needs, and then the teacher is finally evaluated at the end of the year to analyze the fulfillment of the professional development plan.

The district seeks to implement inservice on a voluntary basis. "As Administrators," Haines says, "we try to get the teacher to choose the programs. The more the teacher chooses, the stronger the program. But we also have the responsibility to make sure the teachers are working at a proper level."

The thoroughness in planning, implementing and evaluating the district's staff development programs seems to derive from Haines' general philosophy on what makes inservice programs effective.

> The key thing is getting a district to set up a system. We now have a system in which administrators have been trained in supervision and the same instructional techniques as the teachers. It is important to train administrators first, then the teachers, and then set up an ongoing system to support and monitor the usage of the instructional techniques. The system is the key. My observations have been that where there is no system, staff development is ineffective.

2. San Diego Unified School District

Two years ago, the San Diego Unified School District reorganized its staff development program. Mary Hopper, director of staff development and training, is now responsible for that district's inservice activities for teachers of over 112,000 students in 180 schools. To overcome the difficulties of providing staff development and training programs for over 5,000 teachers and the additional difficulties of limited substitute teacher availability and absence of scheduled inservice days, Hopper takes a systematic yet imaginative, incentive-based approach.

The district has been devised an inservice course method. "We offer 15-hour courses on a districtwide basis," Hopper explains. "Teachers can take a salary credit for completing courses—1 unit of salary credit for taking a 15-hour course." Although this program is of necessity voluntary, inservice related to implementation of curriculum materials is occasionally required of some teachers.

The voluntary courses are advertised through the district's quarterly newsletter and are usually scheduled from 4 to 6 p.m. once or twice a week, or on weekends, to accumulate 15 hours of instruction time. Hopper's staff of one coordinator and five resource teachers are assigned to a given area including a number of different schools. The staff assists in delivering and evaluating the success of an extensive array of topical inservice activities for elementary and secondary teachers. To determine the inservice needs for such a wide range of teachers, several methods are used. "We've done a formal needs assessment districtwide. We also use surveys and telephone followups," Hopper says.

Occasionally, individual schools within the district ask for inservice assistance. "When we work with a school site," Hopper notes, "we visit the site for needs assessment." Once a school's needs are identified, a resource teacher meets with the school staff to explain the program and field questions. "We'll meet with the staff in any way they feel will help them with the program," she says. "For example, a secondary school site sometimes will ask that the resource teacher meet with every department or with the full faculty." Materials related to the selected program are often given out at these meetings. In the case of school sites, scheduling of the activities is usually left up to the school staff.

The problems related to gathering evaluation data on programs are obvious. Gains on student achievement scores are not used as a basis for judging program success, but posttraining surveys and followups are employed. The newsletter containing course schedules also offers teachers the opportunity to evaluate programs on a write-in basis.

Like Haines, Hopper reports that inservice programs are designed in a variety of ways. Some are chosen on the basis of research that validates their value; others are chosen because of their successful implementation elsewhere; and often the district's inservice staff will design their own programs. Teacher and management representatives from the different areas within the district form a Staff Development Advisory Committee, which provides input from the various levels of the district's organization.

As in most school districts, budget limitations and time constraints are her most difficult administrative challenge, Hopper says. Yet the San Diego School District's Staff Development and Training Department has managed to organize and implement an impressive staff development program for an extremely large group of professionals. Her assessment of the overall objectives of

the district's staff development approach includes both the individual and the organization: "I'd say that we're looking at the total picture, and approaching it in a number of different ways."

3 Redwood City Elementary School District

A review of the staff development program in the Redwood City Elementary School District provides a good opportunity to look at the various components an administrator considers when designing new inservice programs for implementation. Bob Beuthel, deputy superintendent, oversees the staff development efforts for 240 teachers at 14 elementary schools (K-8).

The district's highest priority, in recent years, has been to develop a bilingual education program because roughly one-third of the district's 6,500 students have limited English-speaking ability. Despite the budget-reducing effects of Proposition 13 and declining enrollment, the district managed to design and begin implementation of the bilingual program. With that accomplished, Beuthel has now turned his attention to the process of developing a comprehensive approach to staff development after several years of using a "shotgun" approach.

Beuthel began by transferring Connie Williams, previously director of bilingual education, to the position of director of staff development. Beuthel was able to hire two full-time and one part-time resource teachers to assist with the inservice education program.

Several programs are in design or early implementation stages. The district is working on a five-year plan involving the use of microcomputers; part of the plan includes inservice programs related to helping teachers acquire new skills and techniques for computer use. Another program, funded by a grant from the Packard Foundation, will seek to retain seventh- and eighth-grade math teachers, who, due to the staff changes, are teaching math despite it not being their original area of specialty. Beuthel expects this training program to "bring these teachers' skills up to a level that gives them a great deal more confidence and capability in math instruction." Implementation of the bilingual program is a third area that involves substantial inservice activity.

A fourth area concerns curriculum implementation. Inservice in this area relates to what Beuthel calls a "cycle concept," which seeks to evaluate, adopt, and implement new textbooks into curriculum in a three-year cycle. After a two-year period of evaluation and adoption procedures, the third year will use inservice training as a part of the textbook implementation process.

Much emphasis in the coming years will be given to a new program being developed by the inservice education staff. Called the "Effective Teaching Program," this inservice activity will be delivered as a thirty-hour course spread over several days. The classroom will be used as a training site for part of the scheduled time. Like the Teacher Power Program in the Whittier School District, the Effective Teacher Program is derived from different components of several effective teaching models.

The justification and objectives for the program have been made clear in advance: "All teachers need to be introduced to or reinforced in the principles of effective teaching. The Effective Teacher Program has been designed to meet these needs." The objective is "to enhance the quality of instruction in the Redwood City School District" by providing "training in the effective teaching model and...continuing support for the effective teaching participants."

One of the most interesting features in the design of this program is the thoroughness with which the plan is conceived. A team approach to the concept will be emphasized. Beuthel, who describes his role in the project as "a support agent, a catalyst, and a provider of direction for the team," says that a committee composed of staff development personnel, early retirees, and teacher representatives from each school will provide the input to virtually every part of the process. Various other district committees will also review the proposal. This process is intended to build districtwide support before implementation begins. Beuthel hopes that the original committee members will be early trainees in the program; they could then serve as valuable resource persons for subsequent participants.

Although final decisions on several aspects of the program have not yet been made, a list of representative considerations includes cost, suitability of content, trainee preference, and methods for minimalizing interference in the teacher's instructional program. Beuthel expects an extensive evaluation process to occur; some possible evaluation techniques include pre- and post-test evaluation, observations, longitudinal studies, and the opportunity for followup assistance after the training program is completed.

Beuthel sees this last area especially useful as a measure of program success. "If we're really successful," he says, "the requests for followup assistance will be greater. We want the program to be something that people regard as a positive experience." He also hopes that a support group system will form after the 30-hour program is completed so that the staff development will be an ongoing process rather than a limited one.

Much of Beuthel's confidence in the program's potential for success is based on the early support given to it by the district staff, both as individuals and as a group. Says Beuthel: "We've got the people, we've got the network, we've got the desire on the part of the participants to be involved in staff development activities, and we've got the support of our board and administration, so I see nowhere to go but up."

Appendices

A Review of Research on Basic Skills Instruction at the Elementary School Level

To derive a set of dimensions for characterizing inservice programs, we reviewed research on basic skills instruction at the elementary school level. Several sources provided useful information related to the dimensions included in our model. The reader is directed to the original reports (cited in the bibliography) for complete information on the relevant research.

The systems framework developed by the Inservice Teacher Education (ISTE) Concepts Project provided a useful starting point for creating our set of dimensions. Joyce and colleagues (1976) describe the ISTE Project and report that "there are four major dimensions that take the form of systems that link together to form the structure which is ISTE" (p.3) . These four systems are the substantive system, the delivery system, the modal system, and the governance system. We derived some of the dimensions in our model from these systems within the ISTE structure.

Another source for identifying inservice dimensions was the research on curriculum implementation. Fullan and Pomfret (1977) review the research on implementation; we have included as dimensions in our model several items from their list of determinants for effective implementation.

We derived additional dimensions from the literature on general inservice education. For example, Pankratz and Martray (1981) and Nelson (1981) describe models for using inservice education to support the development and installation of new instructional programs. These models suggested several dimensions, such as the use of needs assessment and the relevance of content, that we added to our list.

Cruickshank and colleagues (1979) suggested that the model developed by Dunkin and Biddle (1974) for conceptualizing research on teaching could be used to identify and organize inservice education variables. Some of the variables identified in these reports are included as dimensions in the Delivery System, Teacher Objective, and Student Objective categories in our model.

Finally, the literature on "loose coupling," described by Meyer (1981), suggested the need for identifying dimensions that reflect the relationship between inservice education and school organization arrangements for conducting administrative and technical functions. "Tightly coupled" inservice programs posit a rational, close connection between means (inservice training) and ends (student achievement). However, the theory of loose coupling as it applies to school organization suggests that inservice education would be poorly linked, or loosely coupled to student achievement goals and to other aspects of school organization. Thus, we added a set of dimensions to our Selection and Evaluation section to characterize whether particular inservice programs are tightly or loosely coupled to school outcomes and needs.

B Verification of the Dimensions by Four Experiments

We reviewed the literature on inservice programs for basic skills instruction to identify practices corresponding to the dimensions that have been found to contribute to making such inservice programs effective. For example, we were interested in identifying any research that determined whether the presence of readiness activities (dimension 7 in our model) contributed to the effectiveness of an inservice program.

Four inservice experiments were especially useful for identifying such practices—three on basic skills instruction (Stallings 1980, Anderson and others 1979, and Gage and others 1978) and one in mathematics (Good and Grouws 1979). These experiments are referred to collectively throughout this report as "the four inservice experiments."

In each of the four inservice experiments, the content of the inservice program was a set of instructional techniques that previous research had found to be correlated with measures of student achievement. The instructional techniques used in the four inservice experiments have generally come to be known as "direct instruction." Rosenshine (1976) has identified the research for and the essential elements of direct instruction.

All the programs tested in the four inservice experiments were effective in improving students' basic skills achievement. The results are sufficiently consistent and potent such that educators need to think about incorporating the experimental inservice programs in practice. Since our review,

some additional experiments, yielding similar results, have been reported, for example, Gage (1984) and Gall and others (1984).

Instructional Processes Used in the Four Inservice Experiments

1. Anderson, Evertson, and Brophy (1979)

   The project staff met with teachers to discuss the study. Teachers then read a 33-page manual describing 22 research-validated principles of reading group instruction and took a short quiz on it. Teachers met once again with the project staff to discuss the manual. One subgroup of these teachers was observed for their implementation of the principles throughout the school year. Another subgroup was not observed. (The two trained groups did not differ from each other in the end-of-year student achievement.)

2. Gage and others (1978)

   The "minimal" training group received a training manual and one self-administered test per week for five weeks. The "maximal" group received the same manuals and tests and also attended a two-hour meeting with the project staff each week. In these meetings the teachers discussed, practiced, and studied the techniques; they engaged in role-playing exercises; and they viewed videotapes of a "model" teacher performing the behaviors.

3. Good and Grouws (1979)

   Teachers attended an introductory 90-minute meeting and then read a 45-page manual of research-validated principles of mathematics instruction. Two weeks later the teachers attended another 90-minute meeting in which project staff responded to their questions and concerns.

4. Stallings (1980)

   Each teacher was observed for three days and then given a quantitative summary of the observations as feedback to help change his or her instruction to conform to research-validated specifications. Teachers also attended four two-hour workshops over a 90-day period.

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Chapter 2.2
Literature Review: Effective Staff Development for Computer Integrated Instruction

This is the literature review chapter of Vivian Patricia Johnson's doctorate dissertation done at the University of Oregon and completed in August 1988 (Johnson, 1988). The dissertation focused on the long term residual effects of a particular type of computerintegrated instruction inservice. This chapter of the dissertation is reproduced with the permission of Vivian Patricia Johnson and is copyrighted in 1988 by Vivian Patricia Johnson.

There are four categories of research associated with the process of effective staff development. These are (1) the process of educational change, (2) implementation efforts in education, (3) attempts at educational innovation, and (4) effective inservice practices (see Figure 2). Synthesis of research in all four categories is necessary to understand the general process of effective staff development, the process where changes are introduced and sustained in the educational system.

Part One of this chapter reviews and synthesizes a small segment of this literature, evaluation of computer related inservice. The syntheses was done in order to describe the current level of evaluation of computer inservice, and the methodologies utilized in this research. Part Two summarizes the research findings related to educational changes and effective inservice practices. The summary can be used as a general framework or set of guidelines to design staff development resulting in sustained change. The review was based on a computerized search of the Educational Resources Information Center (ERIC) and Dissertation Abstracts, plus a hand search of Educational Index. See Appendix B for a description of the search strategies.

Part One: Evaluation of Computer Related Inservice

The review of the literature provides an image of computer related inservice that does not follow the prescription for effective inservice described by research. "Schools must use a systematic plan, rather than a haphazard approach, toward achieving this literacy [computer]" (Dickerson and Pritchard (1981) cited in Lovell, 1983, p. 18). "Staff development programs [in computer literacy] should be geared to the concerns and needs of the teachers involved" (Fary, 1984, p. 6). Unless the real concerns of teachers are seriously and systematically considered as a critical variable in the process of change, the use of computers by teachers will take on the usual "hit or miss" orientation so typical of innovations that we educators effectuate (Cicchelli & Beacher, 1985,).

The review identified 36 studies that dealt in varying degrees with the evaluation of educational computing. The modest amount research in this area is surprising considering the field of educational computing is more than thirty years old.

The studies utilized similar evaluation methodologies but exhibited substantial diversity in the evaluation goals and types of objects evaluated. Evaluation goals were used to group the citations to describe the current level of computer inservice evaluation.

While grouping the citations, it became apparent the most common evaluation objects are introductory computer courses, computer curriculum objectives, and computer related training efforts. Grouping also suggested the strongest motivation for conducting evaluation is its requirement in proposals seeking government or private funding for computer related projects.

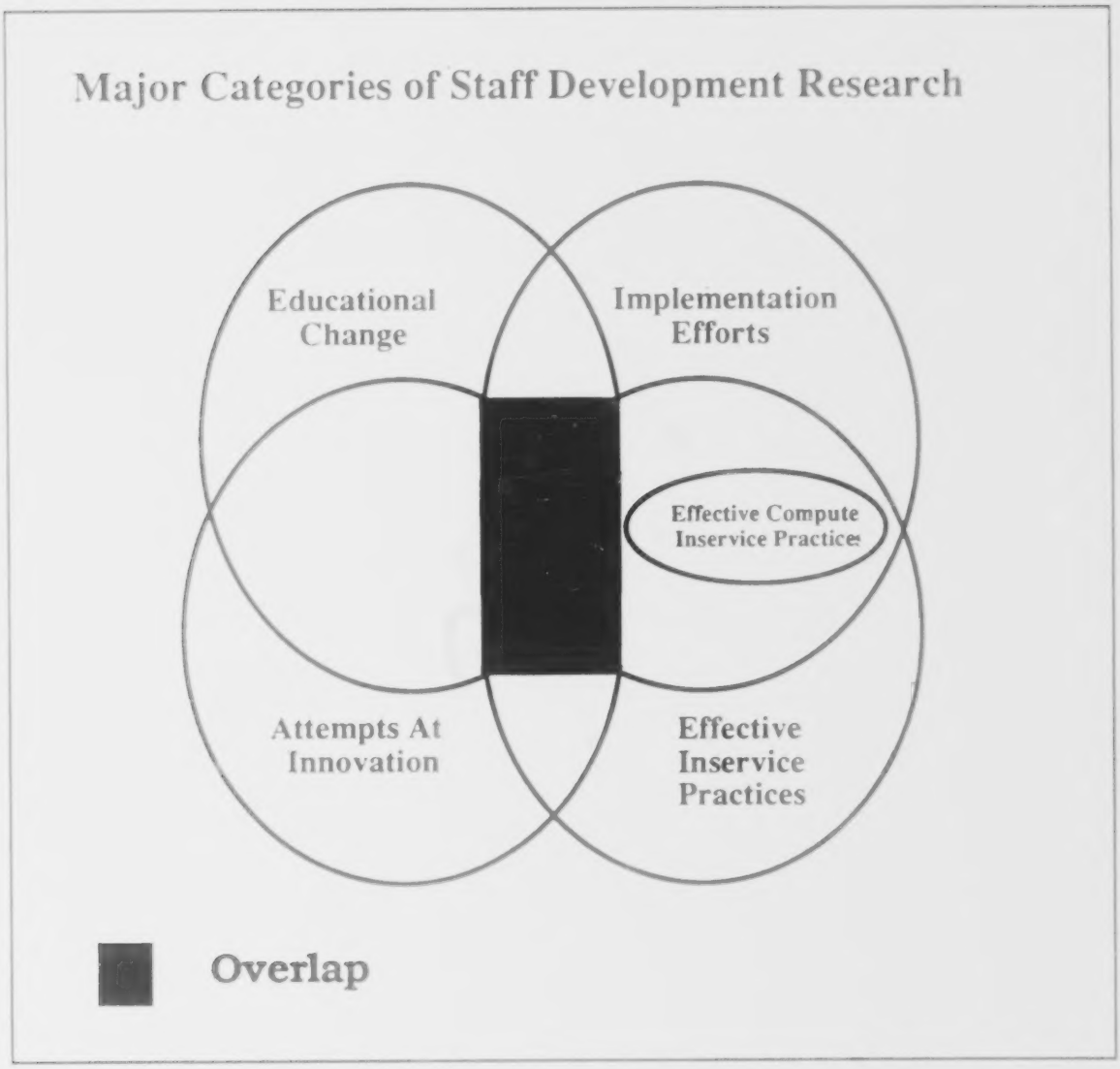

Figure 2. Major categories of staff development research.

Evaluation of Introductory Computer Courses

Approximately one third of the studies were evaluations of computer inservice. The primary goal of these studies was judging the effectiveness of courses designed to promote computer literacy or familiarize teachers with the educational uses of computers (Burker, 1986; Eads, 1986; Feaster, 1985; Harvey, 1986; Nordman, 1982; Ogletree, 1984; Price, 1985; Roblyer & Castine, 1987; Taffe and Weismann, 1982; Vockell, 1981; Vockell and Rivers, 1979; Vockell, Rivers, & Kozubal, 1982; Zduncih, 1985; Zuckerman, 1983). These studies can be classified as formative evaluations using mostly quantitative instruments. The most common research objective was to measure the extent of change in teachers' attitudes toward computers before and immediately after completing an inservice program. In addition to changes in teacher attitude the studies commonly addressed one or more of the following questions.

1. How well did participants learn the course content?
2. What is the relationship between course completion and increased participant computer literacy?
3. What is the relationship between teachers' level of computer literacy and the level of computer use in the classroom?
4. What is the relationship between teachers' attitudes toward computers and the level of computer use in the classroom?
5. Did the course content meet the perceived needs of the participants?
6. What was participant attitude in regard to the course format, inservice delivery system, and course or inservice materials?
7. What revisions would participants like to see in the course or inservice program?

Vockell and Rivers (1979) is one example of a longitudinal follow-up looking at the relationship between course completion and in-class computer use. Their follow-up indicated that participants completing an introductory computer course subsequently did not always use computers in their classrooms. Subjects cited the lack of access to computers as the greatest impediment. The current study examined CI^3 participant perceptions accessing computers and software to determine if access influenced other components of residual effect.

Two studies described the relationship between changes in teachers' willingness to use computers following inservice and actual use of computers in the class (Mitchell,1986; Van Walleghem, 1986). These studies indicated that following their computer inservice, teacher willingness to use computers increased. Unfortunately, increased willingness to use computer did not correlate well with actual computer use in the classroom.

Evaluation of Computer Curriculum Objectives

Still's (1985) formative evaluation is a good example of research related to the appropriateness of district developed computer curriculum objectives. Still's evaluation goals included documenting the extent teachers incorporated the district computer objectives in the classroom and the identification of objectives in need of revision. While the report was positive in its rating of the objectives, it should be noted that the curriculum did not require substantial use of computers. The curriculum emphasized a historic, paper and pencil approach to understanding computers and their use in education. There is no evidence to support that the inservice approach utilized in this study would be effective if the goal were to increase participant use of computers in the classroom.

Only within the last six years has evaluation research focused on measuring the residual effects of inservice programs (Beall & Harty, 1984; Cline et al, 1986; Hanfling, 1986; McMeen, 1986; Mitchell, 1986; Stecher, 1984; Stecher & Soloranzo, 1987, Van Walleghem, 1986; Vockell, 1981; Wagner; 1984). Six of these studies were designed to measure the components of residual effect included in the current study. These six studies examined (1) the kinds of personal and organizational characteristics that correlate with successful computer inservice (CI^3 Inservice Model component of residual effect) (Cline et al, 1986; Stecher, 1984; Stecher & Soloranzo, 1987), (2) the computer use component of residual effect (Hanfling, 1986; Vockell & Rivers, 1979), and (3) how teachers willingness (attitude component of residual effect) to use computers changed following inservice (Mitchell, 1986).

Of the six studies on residual affect, four were associated with two educational computing projects: the IBM Model School Program (Cline et al, 1986; Stecher, 1984; Stecher & Solorzano, 1987), and the ComputerIntegrated Instruction Inservice (CI^3) Project (Hanfling, 1986). Both the IBM Model School Program and the CI^3 Project were unusual in being large scale inservice efforts with significant levels of funding.

The work of Stecher and Solorzano (1987) currently represents the largest effort to identify the characteristics of effective computer inservice. Thirty individuals familiar with educational computing were asked to identify school districts or agencies that were doing an outstanding job of training teachers to use computers. From the names submitted a list of approximately 50 organizations was compiled. This list included over 30 school districts, 12 institutes of higher education and six regional educational centers. The study focused on district based programs and selected eight school districts to participate in the study.

The research design utilized two data collection techniques: a topic-centered interview and direct observation. The interviewees included: the computer administrator, the staff development coordinator, trainers, graduates of inservice, participating teachers, and the school computer coordinator. One direct observation of an inservice class was made for each district. When possible there was also observation of a computer trained teacher working with students on a computerrelated lesson. The study resulted in the identification of twelve practices related to effective inservice programs (see Figure 3).

1. Extensive Practice with Computers
2. Comfortable and Relaxed Atmosphere
3. Appropriate Balance Between Lecture and Guided Practice
4. Individualized Attention
5. Knowledgeable Trainers
6. Detailed Curriculum Guides and Lesson Plans
7. Clear and Relevant Objectives
8. Lesson-Related Materials and Handouts
9. Inservice Lessons Linked to Instruction
10. Peer Interaction
11. Voluntary Participation
12. Strategies for Teaching Heterogeneous Classes

Note. From *Characteristics of effective computer inservice programs* (p. 54) by B. M. Stecher and R. Solorzano, 1987, Pasadena, CA: Educational Testing Service. Copyright 1987 by Educational Testing Service. Reprinted by permission.

Figure 3. Twelve effective computer inservice practices identified by Stecher and Solorzano (1987).

Miscellaneous Evaluation Research

A limited amount of work (6 studies) is related to the development of district, state, or country wide guidelines for monitoring computer implementation (Carlson, 1986; Coe, 1985; Teaching, Learning and Computer: 1984 Information Kit, 1986; National Institute of Education, 1986; School District Planning, 1986; Still, 1985). Incorporated into each guideline was the need for evaluation of staff development efforts, but specific evaluation methodologies and objectives were generally lacking.

The guidelines suggested the inclusion of an inservice component in effective computer implementation plans and recommended evaluating the inservice provided. Unfortunately, the guidelines assume implementation of computers can be expected if the majority of staff participate in and indicate satisfaction with the inservice programs. The guidelines lack methodologies for measuring the extent computer inservice achieved its goals and the level of computer implementation in schools.

Two evaluations studies were related to California's Teacher Education Centers (TEC) (Brandes & Padra, 1985; Wagner, 1984). TEC were regional centers set up by the state of California to provide staff development services. The evaluation goals of these studies are typical of research validating that government funds were spent in an appropriate manner. These studies described the type of staff development programs offered by the TEC, and the number of participants in each category. Unlike other studies, these evaluations were not limited by small sample size, a major limitation in quantitative designs. With the large sample size it is unfortunate the evaluation designs did not include any attempt to measure how effective the computer related inservice programs were in increasing classroom use of computers.

An ever smaller amount of evaluation research is related to judging staff development approaches utilizing one or more of the the following formats: (a) computer assisted instruction (CAI), (b) computer managed instruction (CMI), and (c) distance education via satellite. This research was not germane to the current study.

Summary of Evaluation Research Literature

The review of the evaluation literature indicated that research to determine the effectiveness of computer inservice is limited and focused on short term effects. The most frequently evaluated objects are courses and new programs. Typically, evaluation objects have connections to one or more government agencies and involve significant levels of financial and personal resources.

The most frequent evaluation goals are validating that funds were spent on the development and/or initiation of the proposed program or course, and making quantitative judgements of whether the inservice occurred. Only two studies attempted to judge the effect of computer inservice on the subsequent level of in-class computer use (Hanfling, 1986; Vockell & Rivers; 1979).

The following conclusions are supported by the literature review.

1. The majority of computer inservice is not evaluated. The motivating force for most evaluation research is related to grant proposal guidelines.
2. Evaluation of computer implementation at the district, state, and country wide level is recommended, but goals are limited to determinations of whether inservice programs were initiated.
3. The most frequently evaluated objects are computer related courses. The most common formative evaluation goal is determining the appropriateness of course content. In addition, some studies examine how computer courses offered as inservice affect participants' computer literacy and attitudes toward educational uses of computers.
4. Descriptive evaluation methodologies appropriate for studying the residual effect of computer inservice are currently not well defined or tested.

Stecher and Solorzano (1987) identify two problems that result from the lack of evaluation research. One, without evaluation research it becomes difficult to judge the relative merits of inservice programs. Two, without evaluation research developers have little data to guide them in developing new programs and improving existing ones.

Part Two: Summary of Major Research Findings Related to Effective Staff Development

The Meaning of Educational Change by Michael Fullan is the first attempt to synthesize the major findings in the four categories of research associated with the process of effective staff development (see Figure 2). Two findings from this body of research are particularly important to consider when designing effective staff development. The introduction of innovations, including computer innovations, needs to be viewed as a process influenced by numerous factors (Fullan, 1982; Hall, 1974; Hall & Rutherford, 1983; Loucks & Hall, 1981). Equally important is the knowledge that successfully implementing change is difficult and more complex than one might expect (Fullan, 1982, Parish & Arends, 1983). The complexity of the problem explains the low success rate; only twenty percent of attempts at innovation or revision in the educational process are judged successful (Mann cited in Parish & Arends, 1983). However, the positive message is that educational change is possible. This researcher supports Fullan's belief that "by making explicit the problems of planning and coping with change, we gain further understanding of why certain plans fail and other succeed" (p. 7), thereby increasing the likelihood that new efforts at innovation will be successful.

This segment of the literature review will focus on research related to the factors that facilitate or inhibit the process of change. The factors are discussed using a modified form of Fullan's scheme of factors affecting implementation. Two categories from Fullan's scheme are included in this segment of the literature review: characteristics of change and characteristics of effective staff development.

Characteristics of Change

Several characteristics of change significantly influence the success rate of attempts at innovation (Fullan,1982). Change is complex, difficult, highly personal, and multidimensional. In general, "simple changes are easier to carry out, but they may not make much of a difference. Relatively complex changes promise to accomplish more" (p.59). Complex change is more likely to be successful when the change is introduced in incremental components.

The multidimensional aspect of change has significant implications for the design and delivery of effective staff development. Fullan believes there are at least three dimensions related to change. The following dimensions must be addressed if change is to occur.

> (1) the possible use of new or revised *materials* (direct instructional resources such as curriculum materials or technologies), (2) the possible use of new *teaching approaches* (i.e., new teaching strategies or activities), and (3) the possible alteration of beliefs (e.g., pedagogical assumptions and theories underlying particular new policies or programs, p. 30).

Fullan (1982) has also identified four major aspects pertaining to the nature of change itself that influence subsequent implementation: (1) need, (2) clarity, (3) complexity, and (4) quality and practicality of materials. Fullan's synthesis supported the assertion that teachers are willing to adopt change at the individual classroom level if certain conditions are met. First, the innovation addresses a priority need. Second, the essential features of the innovation are clearly defined and practical. Finally, the plan for implementation is based on a realistic assessment of the difficulty of the change, skill required to accomplish the change, and the extent the change will require alterations in beliefs and teaching strategies.

The research of Hall also addresses the complex, difficult, and personal nature of change. Loucks and Hall (1981) view

> changes as a process, not an event; it takes time and continual adjustments in attitudes, skills, resources, and support to be successful. Second, change is accomplished by individuals, not

> institutions; that is, before an institution can be said to have changed, individuals must behave differently. We further believe that change influences people differently, and so is a highly personal experience. (p. 3)

Staff development efforts that do not address these characteristics of change are much more likely to be unsuccessful.

The Concerns-Based Adoption Model (CBAM) proposed by Hall and others provides a framework and common language to describe and understand the process that individuals move through with regard to acceptance and utilization of an innovation. CBAM represents a common sense approach to the adoption and implementation of innovations. CBAM research has developed a set of diagnostic tools that enable change agents to systematically collect information to guide their intervention strategies and facilitate change.

CBAM "was developed to represent the highly complex process entailed when educational institutions become involved in adopting innovations" (Hall, 1974, p. 5). CBAM is composed of three descriptive dimensions: (1) Seven Stages of Concern About Innovation, (2) Levels of Use of the Innovation, and (3) Innovation Configuration (Loucks & Hall, 1981). These dimensions "are used to diagnose the 'state' of a change effort at any point in time and to monitor its progress longitudinally" (Loucks & Hall, 1981, p. 8). The goal of CBAM is to develop an understanding of how change occurs from the teachers' point of view and to provide change facilitators with information for assisting teachers in implementing innovation (Hall, 1978).

CBAM research has identified and verified the existence of seven stages of concern (SoC) about an innovation (Hall, 1974; Hall & Loucks, 1978; Hall & Others, 1977). The stages are: (1) awareness, (2) informational, (3) personal, (4) management, (5) consequence, (6) collaboration, and (7) refocusing (see Figure 4). These stages are equivalent to Fuller's (1969) developmental stages of preservice teachers.

Stage	Description
6	REFOCUSING: The focus is on exploration of more universal benefits from the innovation, including the possibility of major changes or replacement with a more powerful alternative. Individual has definite ideas about alternative to the proposed or existing form of the innovation.
5	COLLABORATION: The focus is on coordination and cooperation with others regarding use of the innovation.
4	CONSEQUENCE: Attention focuses on impact of the innovation on students in his/her immediate sphere of influence. The focus is on relevance of the innovation for students, evaluation of student outcomes, including performance and competencies, and changes needed to increase student outcomes.
3	MANAGEMENT: Attention is focused on the processes and tasks of using the innovation and the best use of information and resources. Issues related to efficiency, organizing, managing, scheduling, and time demands are utmost.
2	PERSONAL: Individual is uncertain about the demands of the innovation, his/her inadequacy to meet those demands, and his/her role with the innovation. This includes analysis of his/her role in relation to the reward structure of the organization, decision making, and consideration of potential conflicts with existing structures or personal commitment. Financial or status implications of the program for self and colleagues may also be reflected.
1	INFORMATIONAL: A general awareness of the innovation and interest in learning more detail about it is indicated. The person seems to be unworried about himself/herself in relation to the innovation. She/he is interested in substantive aspects of the innovation in a selfless manner such as general characteristics, effects, and requirements for use.
0	AWARENESS: Little concern about or involvement with the innovation is indicated.

Note. From "Teachers concerns as a basis for facilitating and personalizing staff development" by G. E. Hall and S. Loucks, 1978, *Teachers College Record*, 80 (1), p. 41.

Figure 4. Descriptions of the seven stages of concern about an innovation.

CBAM research supported the hypothesis that SoC is a developmental process. Individuals in their initial approach to an innovation will have concerns different from those they have after using the innovation. More advance stages of concern will be identified with subsequent cycles of innovation use. A cycle is the time required to move through all stages of an innovation once. However, these developmental processes may become blocked or go dormant at any one of the seven stages of concern (Hall, 1974).

The developmental nature of an individual's movement through various stages of concern has important implications for change agents. To facilitate change staff development must address an individual's current stage of concern. Three different tools are available for tracking these developmental changes. They are (1) the SoC questionnaire, (2) a written response from individuals to open-ended questions concerning the innovation, and (3) informal conversations with participants about the innovation (Hord & Hall, 1984).

"Stages of concerns has been proposed as a diagnostic tool for use by counselors, administrators, staff developers and other change facilitators who are responsible for the timing and delivery of staff development experiences" (Hall & Rutherford, 1983, p. 21). CBAM utilizes the notion that individuals involved in the innovation process need information and training which is matched to their current Stage of Concern. As they become more experienced with the innovation, developmental changes occur in their concerns profile. Change facilitators who track the concerns profiles of their audience can use SoC as a data source to determine the content, design, and timing of interventions.

Levels of Use (LoU) is a diagnostic tool which can be used by change agents to answer the following questions. Is the innovation there? Do all teachers use the innovation the same way? Does the use of the innovation change over time? What is the shape of the innovation? What is the use of the innovation across teachers within the same building? (Hall, 1977). Only when a change agent has data related to these questions can he/she judge the progress of an adoption or an innovation. LoU provides information on which change agents can base decisions of content, design, and delivery of support activities.

The final dimension of the CBAM model is the innovation configuration (IC). IC is a process for identifying key components of the innovation and describing how the innovation is being used by different people (Hall, 1981). The checklist can be used with direct observation or during the LoU interview (Hall, 1981). The Innovation Configuration checklist helps change agents collect information to determine if adaptations made by users of the innovation are acceptable with the developers' concept of the innovation. The use of the IC checklist enables the change facilitator to collect information for data-based decisions on what is actually happening in individual classrooms. Only when the results of the IC are consistent with the change agent's expectations should an evaluation of the effectiveness of the innovation or change be considered.

Characteristics of Effective Inservice

The research literature associated with research based evaluation of inservice is limited. This segment of the literature review concentrates on four major studies interested in the identification of effective inservice practices. The Rand Study, the best known study in this area, examined 300 educational innovations to determine why some projects succeeded and others failed. The sample was composed of 852 administrators and 689 teachers. The design included field studies to observe projects in action and a follow-up two years after the original research was conducted. The follow-up included resurveying 100 projects and revisiting 18 to identify and describe long-term residual effect.

The Rand Study concluded effective inservice programs have some characteristic features. Effective programs were judged to have concrete application to the classroom. The most effective programs provided long-term assistance to participants. Assistance was in the form of a local resource personnel who could provide "on-call" advice. Effective programs were designed to be teacher specific, meeting the local needs and concerns of participants. Finally, principals provided active support and participated in effective inservice.

The work of Gall and Renchler (1985) represents a major effort to describe a research based model of effective staff development. The study examined the research literature to identify effective inservice practices. "A practice was considered effective if it could be shown to have at least one of three results: teachers incorporated the content learned from the staff development program in their classroom instruction, teachers and administrators were satisfied with the program, and students improved their achievement in basic skills. In a second stage, the team surveyed teachers and administrators to see whether actual inservice programs utilized these research-validate practices" (p. vii). [Editor's Note: The Gall and Renchler article is included as Chapter 2.1 of this book.]

Based on the literature review of basic skills instruction Gall and Renchler derive a set of six generic dimensions for characterizing inservice programs. The dimensions are: (1) teacher objectives, (2) student objectives, (3) delivery system, (4) organizational context, (5) governance,

and (6) selection and evaluation. Twenty-seven effective inservice practices were associated with the six dimensions (see Appendix C).

Gall and Renchler also conducted a survey of teachers and administrators ". . . to see whether actual inservice programs utilize these research-validated practices" (p. vii). The survey data indicated the majority of staff inservice did not incorporate the effective practices that emerged from the literature review.

For example, according to the research, the most effective programs are designed for the purpose of school improvement. But in actual practice, the survey showed that 67 percent of staff development activities are for teachers' personal professional improvement. The activities also paid little attention to student achievement as a desired outcome, pursued many goals instead of a few priority ones, and neglected direct instruction strategies. All these characteristics are contrary to the recommendations emanating from research on effective staff development programs. (p. vii).

Wade's (1984-85) meta-analysis of 91 inservice studies revealed the following effective inservice practices.

> Inservice training that includes both elementary and secondary teachers is often more effective than inservice for either group separately.
>
> Inservice is most successful when participants are given special recognition for their involvement, are selected on a competitive basis, or are designated to participate.
>
> Regardless of who conducts inservice sessions (trainers come under many different job classifications), teachers are more likely to benefit when they learn on their own. Similarly, of all the different types of training structures, independent study is the most effective.
>
> There is no magical combination of methods for successful inservice. Nevertheless, inservice programs that use observation, micro teaching, audio and visual feedback, and practice—either individually or in some combination—are more effective than programs that do no use these methods.
>
> There is no evidence that "coaching" greatly enhances instructional effectiveness. At best, it is moderately effective.
>
> Inservice is less successful when participants are regarded as major contributors. Programs are more effective when the leader assumes the role of "giver of information" and the participants are "receivers of information. (p. 54)

Korinek, Schmid and McAdams (1985) located over 100 reports that meet four criteria:

> (a) the work was conducted in the United States; (b) it was published subsequent to 1957; (c) endorsements or practices, specific recommendations and/or conclusions about inservice for practicing teachers were included in the report; and (d) it was published in a refereed journal if a comparison or test of procedures was described" (p. 33)

Seventeen studies meet all the criteria and were examined for effective inservice practices.

"Fourteen 'best practice' statements were derived by tallying the number of times a specific practice was mentioned in the reports. If a recommendation had six or more tally marks it was included as a best practice" (Korinel et al., p. 34). Each best practice was also associated with the three most common models of inservice programs: information transmission, skill acquisition, and behavior change. The following are the fourteen best practices.

1. Effective inservice is usually school-based rather than college-based (skill acquisition, behavior change).

2. Administrators should be involved with the training and fully support it (information transmission, skill acquisition, behavior change).

3. Inservice activity should be offered at convenient times for participants (information transmission, skill acquisition, behavior change).

4. Inservice should be voluntary rather than mandatory (information transmission).

5. Rewards and reinforcement should be an integral part of an inservice program (information transmission, skill acquisition, behavior change).

6. Inservice programs should be planned in response to assessed needs (information transmission, skill acquisition, behavior change).

7. Activities which are a general effort of the school are more effective than "single shot" presentations (skill acquisition, behavior change).

8. Participants should help plan the goals and activities of the inservice training (skill acquisition, behavior changes).

9. Goals and objectives should be clear and specific (information transmission, skill acquisition, behavior change).

10. Inservice activity should be directed at changing teacher behavior rather than student behavior (behavior change).

11. Individualized programs are usually more effective than those using the same activities for the entire group (skill acquisition, behavior change).

12. Participants should be able to relate learning to their back home situations (information transmission, skill acquisition, behavior change).

13. Demonstration, supervised practice, and feedback are more effective than having teachers store ideas for the future use (skill acquisition, behavior change).

14. Evaluation should be built into inservice activity (information transmission, skill acquisition, behavior change) (p. 35).

The literature review of change research and effective staff development indicated that educational change is difficult and takes time. When change is complex or different from the status quo it will be harder to accomplish and take longer. Planning for change is a process. The process must address a validated need for change. The change should be clearly defined and practical. Inservice is a crucial component of the change process and should be designed to incorporate research based effective practices.

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Chapter 2.3
Questions and Answers:
Ask Dr. Dave

This chapter contains a number of questions that are frequently raised by computer integrated instruction inservice providers. For each question I give a discussion of the underlying ideas and an analysis designed to help you formulate an answer appropriate to your inservice situation. You should be aware that there is a substantial difference between the "theoretical best" way to design and present an inservice, and the reality of what most inservice providers face. Generally speaking, an actual inservice is a carefully orchestrated collection of compromises. As with all teaching, you take advantage of your strengths and you do your best under the circumstances.

Q1. What are your major goals when you organize and run a workshop?

I always hold three goals in mind.

1. (*For Myself*) I expect to learn, to grow, and to have fun from the workshop. Designing and conducting workshops is hard work. It is nearly impossible to make a living conducting workshops. Certainly there are easier ways to make a living. But I have a lot of fun doing workshops. This type of work provides me with an "intellectual high" that seldom occurs in the rest of my professional work.

2. (*For Participants*) I expect participants will learn and grow from the experience of being in the workshop. They will be facilitated in making changes to their knowledge, attitudes, and skills that are relevant to improving their teaching.

3. (*For Students*) I expect that our educational system will be better, and that students will get a better education, as a consequence of my organizing and facilitating a workshop. That is, I expect that participants will make changes in what they teach and how they teach it.

Notice that I have considerable control over the first goal, less control over the second goal, and even less control over the third goal. With this set of goals, there is always room for improvement.

Q2. In your opinion, what is the most effective type of inservice?

I like to think of two general categories of inservice. First, there is the traditional large group inservice. Here a group of teachers come together in a class-like setting, and they receive instruction from an inservice facilitator. This can be successful if it is carefully done and if adequate follow-up support is available. There is a substantial body of research literature on how to design and conduct an effective large group inservice.

A second approach, which I believe is far more effective on average, is one-on-one inservice conducted in the participant's school—indeed, perhaps even in the participant's own classroom and demonstrating the desired behaviors with the participant's students. Most often in this case the inservice facilitator is a fellow teacher within the school building or school district. The overall activity may consist of the following sequence of events:

1. A teacher approaches the inservice facilitator and indicates a desire to learn. (Notice that this requires a high trust level, and building this trust level requires personal contacts.)

2. The teacher and inservice facilitator discuss the general area of desirable knowledge, attitude, and skills, that might be expected as an outcome of working in this area, why it is important, how long it might take, what each might contribute to the process, etc.

3. The inservice facilitator models the desired behavior, either in the teacher's classroom or with some other set of students. The teacher participates as a student.

4. The teacher spends time learning the skills through study and practice, and receives the needed help from the inservice facilitator.

5. The teacher practices the desired behavior in his or her classroom, with the inservice facilitator serving as an assistant and as a source of feedback.

6. The teacher spends additional time studying the new material and lesson plans provided by the inservice facilitator, and may work on modifying these lesson plans. Help is available as needed from the inservice facilitator.

7. The teacher tries out the new lessons in his or her classroom, gradually developing the self confidence and skills needed to routinely use the new ideas and materials.

8. Additional help is available from the inservice facilitator as needed. The inservice facilitator gradually brings in new, higher level ideas, as the teacher makes progress and becomes ready for the additional ideas.

At first glance, this approach to inservice education appears to be much more expensive than the large group, traditional approach. However, it is much more likely to produce the desired change in a teacher. Moreover, it is possible to organize a school's faculty so that this type of inservice is commonplace and may have very little cost. The idea is that every teacher in a school building should have some inservice responsibilities. That is, every teacher should have one or more areas of inservice expertise. As part of their professional responsibility, they are to remain current in their inservice speciality areas and to provide one-on-one inservice to their fellow teachers. School and district inservice funds are provided to help each individual teacher develop and maintain their areas of inservice expertise.

Some schools use this approach to inservice. It builds a high level of professionalism and collegiality. However, this approach to inservice is by far the exception, rather than the rule. Thus, the remainder of this chapter focuses on traditional, large group inservice.

Q3. **Please provide us with a short model for an effective inservice series.**

The National Science Foundation project developed its inservices using the following nine-part model. You may need to modify it to fit your own particular group inservice situation.

1. Do a needs assessment. A number of needs assessment ideas are discussed in this book. Many school districts have developed a long-range plan for computer use and a more general long-range plan for their schools. Such long-range planning provides a good starting point for a needs assessment.

2. Design the inservice and make the necessary arrangements for facilities. Give careful consideration to holding some or all of the sessions in the schools of the participants.

3. Recruit participants. Keep in mind the desirability of having a critical mass of participants from each school that is participating, and the strong desirability of having administrative support and participation. By and large it is easier to work with participants who have relatively homogeneous computer backgrounds and teaching interests.

4. Carefully and fully prepare the content of the inservice series. Prepare handout materials.

5. Do an inservice session. Conduct informal and formal formative evaluation as seems appropriate.

6. Participants leave the inservice session adequately prepared to implement some change in their classroom.

Note: Repeat 5 and 6 for each inservice session. Each session provides follow-up support to the previous sessions. Provide time in each session for doing the necessary follow-up support.

7. At the end of the inservice series, do some summative evaluation. From the point of view of the participants, what went well, and what didn't? What could be improved, and what changes in emphasis would make the inservice series more valuable to participants?

8. After the inservices series ends, continue to provide follow-up support to the participants.

9. Six months to a year after the inservice series ends, gather some data on the long-term residual effect of the inservice. Are the participants exhibiting the behaviors that the inservice was designed to promote?

Q4. **What are some of the major failings in traditional large group inservice for integrating computer as a tool into the curriculum?**

There are many flaws in the design of most such inservices. Her are a few of them:

1. The inservice is not based on an adequate needs assessment, with the needs assessment firmly rooted in long-range planning for computer use in schools. (Frequently the school and school district lack a long-range plan for computer use. Thus, they lack the carefully considered and carefully designed long term support of the key stakeholders who would be affected by increased use of computers in schools.)

2. Often a "one shot" approach is used, or there is only a very limited amount of inservice available. Research suggests that one shot inservices are rarely effective. Change literature suggests that educational change takes a long time and substantial effort. Generally it takes a great deal more inservice than is provided, and it needs to be spread out over a period of years.

3. Most computer integrated instruction inservice does not provide adequate follow-up support. Only the "early adopters" tend to be able to take the results of a one shot inservice with little or no follow-up support, and actually make substantial changes in what they do in their classrooms. This is a very small percentage of teachers.

4. Most CII inservice focuses almost entirely on helping teachers learn to use the particular computer tool under consideration. Little or no time is provided to study needed changes in the curriculum, learn to deal with new classroom organization and management situations, develop and critique lesson plans, etc. The inservice focus tends to be on the "key presses" and details of using a particular piece of software rather than on underlying theory and higher-order thinking and problem solving skills. The typical CII inservice would be more effective if it achieved a better balance between the lower-order skills (the key presses) and the higher-order skills (problem solving) inherent to the use of the software being studied.

5. Most CII inservices focus on single individuals (one person per school, or one per school district) rather than concentrating attention on a critical mass of teachers in a single school. It is essential to define the educational unit of change (large department, a grade level, a school) and have a critical mass of inservice participants from that unit. The collegiality of a substantial support group contributes substantially to the successful implementation of what one learns in an inservice.

6. Most CII inservice does not have realistic expectations for desired outcomes. For example, an elementary school teacher is taught how to do process writing in a word processing environment. But there are only four computers in that teacher's school. Or, a secondary school math teacher is taught how to use a spreadsheet to present a variety of math topics and solve a variety of problems. But the computer lab in the teacher's school is at the other end of the building and is heavily scheduled for computer programming and computer literacy classes. Also, the school's mathematics instructional focus is dominated by the state mandated standardized tests, and computers cannot be used on these tests.

7. The nature and extent of the handout material is inadequate. The actual inservice time is quite short. Handout materials should be designed to help make maximum use of that time. Inservice participants are expected to carry what they are learning back to their own classrooms. Thus, sample lesson plans are important. Inservice participants are expected to continue to learn on their own after the inservice ends. The handout materials should facilitate further, independent learning.

8. There is little or no direct support from the school administration or school district administration. (Research strongly supports the contention that little classroom change is apt to occur without such explicit support. It is highly desirable that school administrators participate in the inservice along side their teachers.)

9. There are relatively few incentives for teachers to make substantial changes in their curriculum. But effective use of computer integrated instruction generally requires substantial changes in both the content and the conduct of the curriculum.

This list could easily be extended. The major point is that there is a lot of room for improvement. We should not be surprised by the fact that previous CII inservice has not been particularly effective in producing change in our schools.

Q5. **In light of the previous question and answers, might we be better off if we just quit offering computer inservices? Perhaps they are doing more harm than good. Perhaps the resources being put into the CII inservice effort would better be spent addressing some other school issue.**

This is a hard question to respond to. I suspect every computer inservice facilitator can point to both successes and failures. Sometimes a failure has long term consequence—a teacher is turned off from computers for many years.

Moreover, many of the successes may be the early adopters—the small percentage of teachers who are very quick to learn new ideas and to integrate their use into the classroom. Thus, there is some basis for asking whether we should discontinue the major push on CII inservice.

However, I feel this would be a major mistake. The key issue is that the computer as a tool is of growing importance in our society and for educated people who make use of their education. Computers are at the heart of the technological change that is driving our society. Our schools have just barely scratched the surface of the educational problem of tool uses of computers. All of the inservice that has been done so far is a tiny percentage of what needs to be done. We know how to do effective CII inservice. There are many teachers who are qualified to be effective CII inservice providers. I am confident that carefully designed and appropriately facilitated CII inservices will do far more good than harm, and they will help to improve our educational system.

This may be a good place to put in one more plug for one-on-one inservice. This type of inservice is highly effective in producing change and provides a high level of satisfaction to the inservice provider. Moreover, it can form a foundation for increased levels of professionalism in a school. Such increased professionalism can make a substantial contribution to an overall increase in the effectiveness of a school.

Q6. How can I get to be an inservice provider?

Here are four answers. I am sure that you can think of others.

1. Begin by practicing in a one-on-one mode. It is easy to find opportunities to do this type of inservice.

2. Find someone who is a very good inservice provider who does the types of inservices you want to learn to do. Participate in that person's workshop. Then participate a second time, but as a volunteer assistant. (You may need to participate still a third time, as an assistant who is taking on a substantial amount of the responsibility of facilitating the inservice.) Then you will likely be ready to try it on your own.

3. Take a course on how to organize and run an effective inservice. (Read this book.) As part of the homework for that course, organize and run a short inservice under the supervision of course participants and the course instructor.

4. Get yourself put into a position where you are committed to doing an inservice. For example, when you see that teachers in your school or district would benefit from an inservice covering topics that you know quite well, volunteer to organize and facilitate such an inservice. (Typically you should not expect to be paid for this work. The first couple of times you do an inservice you will probably learn more than the participants.)

Q7. How much time should I expect to spend to prepare for an inservice large group presentation?

I assume that you are highly knowledgeable and experienced in the topic area of the inservice. How much time it takes to be adequately prepared varies substantially with the nature of the content to be presented, the nature and quantity of handouts, and so on. Roughly speaking, you should plan on spending 10-20 hours preparing for each hour of inservice the first time you do a particular inservice. The second time you do the same inservice plan on spending about 5-10 hours of preparation time for each hour of inservice. Subsequent presentations of the same inservice may require 2-4 hours of preparation for each hour of inservice.

Of course, there are some professionals who do the same inservice over and over again. Indeed, some make a living from offering a small repertoire of inservices. The preparation time in this case gradually decreases. Even here, however, it is highly desirable to spend a reasonable amount of time examining new ideas, new materials, and ways to improve the inservice.

Perhaps the main point is that initially it takes many many hours of work to prepare for each hour of inservice. Administrators who pay for the development and presentation of inservices are seldom aware of how much work is required. They do not provide adequate release time and pay to make it worthwhile for a teacher to want to design and conduct an inservice.

Q8. What are necessary or desirable qualifications to be a good computer integrated instruction (CII) inservice facilitator?

This question is too broad to give a really good answer. However, a good answer would address several major areas:

1. Teaching and inservice facilitation skills. The inservice facilitator should be a good teacher and should be especially skilled in working with his or her peers. "People" skills, good interpersonal skills, are essential. For CII inservice, a good balance between "high-tech" and "high-touch" characteristics is highly desirable.

2. Theoretical and practical knowledge of the inservice topic. The inservice facilitator should be highly knowledgeable and experienced in the topic of the inservice. A broad-based background, much broader than just the topic to be covered, is highly desirable.

It is highly desirable that the inservice facilitator have recent classroom experience in using computers with kids. The inservice facilitator who can say, "I used this idea in my classroom last week, and it really worked well" has a distinct advantage over the inservice facilitator who has long since ceased being a classroom teacher.

3. Leadership for educational change. The inservice facilitator should be an experienced educator and an educational leader with a vision of how CII will lead to better and more appropriate education for students. The inservice facilitator is a key educational change agent and therefore should be willing and able to take an assertive stance for changes that will lead to improving our school system.

Q9. What is an appropriate balance between hands-on and off machine activities in a CII inservice?

Any inservice should be designed to accomplish specific educational objectives. If the goal is to change the classroom teaching behavior of the participants, then the inservice should be carefully designed to help participants learn the behavior that is expected of them and to practice the desired behavior.

For a CII inservice, the underlying goal is for participants to return to their classrooms and integrate tool uses of computers. This requires a change in course content and philosophy, as well as having students actually learn to use computers. Surveys of CII inservice participants suggest that they most prefer that approximately 2/3 - 3/4 of an inservice be spent in a hands-on mode. However, chances are that this is far too much time to spend in that mode. It leaves too little time for working on the changes in course content and underlying philosophy that are essential parts of the desirable classroom change.

Remember, a good inservice session includes most or all of the following:

1. An overview presentation of the general topic and underlying theory.

2. Demonstration of desired performance.

3. Participants learn to use the materials and practice using them.

4. Participants discuss potential applications in their classrooms, how the CII tool being studied fits in with their curriculum, and how it leads to changes of their curriculum.

5. Participants practice working with materials that they will use as they implement their new knowledge and skills in the classroom.

6. (Of course, a good inservice also has follow-up activities, but that is not pertinent to this particular discussion.)

A careful analysis of the above considerations suggests that there will often be a conflict between the desires of participants and the best judgement of the facilitator. The inservice facilitator should be aware that the actually inservice meeting time is quite limited and should strongly encourage participants to do some of the needed computer practice on their own, outside of the formal inservice meetings times. However, the inservice facilitator should also be aware that teachers are very busy and many have difficulty finding the necessary time to practice what is being covered in the inservice.

Q10. Can you give us a comprehensive list of effective inservice practices for computer integrated instruction?

A good starting point is the list developed by Stecher and Solorzano that is discussed in Chapter 2.2 of this book and is given below.

1. Extensive Practice with Computers
2. Comfortable and Relaxed Atmosphere
3. Appropriate Balance Between Lecture and Guided Practice
4. Individualized Attention
5. Knowledgeable Trainers
6. Detailed Curriculum Guides and Lesson Plans
7. Clear and Relevant Objectives
8. Lesson-Related Materials and Handouts
9. In-service Lessons Linked to Instruction
10. Peer Interaction
11. Voluntary Participation
12. Strategies for Teaching Heterogeneous Classes

I have frequently discussed this list in effective inservice workshops and then asked participants to add to the list. Participants in these workshops have provided me with a long list of items that they recommend as effective, based on their own personal experiences. A number of their suggestions are given below. Some overlap with the Stecher and Solorzano list.

1. Provide adequate time for creativity, thinking, and problem solving.

2. Check and recheck your hardware and software. Design your inservice so that you have a reasonable fall back position if there is a major hardware failure (or a power failure).

3. Model enthusiasm. Also, model the types of instructional behaviors that you want the inservice participants to learn.

4. Do an adequate needs assessment well in advance of the inservice.

5. Make provisions so that the inservice participants will be able to practice the key ideas of the inservice between inservice sessions.

6. Draw on the strengths of the inservice participants. For example, if some have experience in the areas that are being covered, make use of their experience. Pair up beginners with more advanced computer users in the hands-on activities. Instruct the more advanced computer users that their role is to learn how to help a beginner, and to practice one-on-one inservice techniques.

7. Make sure that the inservice content is appropriate to the hardware and software that is available to the teachers in the inservice. (They can't implement the ideas of the inservice unless they have appropriate hardware and software.)

8. From time to time divide inservice participants into homogeneous subgroups and provide adequate time for them to discuss how they will implement the new ideas in their own classrooms.

9. Build collegiality and develop this into a follow-up support system.

10. Make sure that your visuals are of good quality and large enough so that participants can easily see them. Indeed, you may want to give participants a copy of all of the visuals and to take notes on these sheets.

11. Provide lots of time for individual questions.

12. Do a formative evaluation and make appropriate adjustment to the content of an inservice series based on the formative evaluation.

13. Provide follow-up support and encouragement.

14. Design assignments so that they are practical and relevant. For example, a good assignment may be one requiring the participant to implement some of the inservice ideas into his or her classroom, and then report on the results.

15. Provide very good refreshments for breaks.

16. Start on time. End on time, or a couple of minutes early.

17. Be aware that most teachers are quite busy and feel that they are over worked and under appreciated.

When I do this exercise in effective inservice workshops, I find that the lists generated cover most of the ideas in the Stecher and Solorzano list and include a

number of additional practical suggestions. Most inservice facilitators have attended dozens of inservices themselves and have a good grasp of what works well and what is ineffective in an inservice.

Q11. How important is it that inservice participants develop collegiality and a peer support system?

Collegiality and peer support are very important. Research suggests that inservice is more effective if it focuses on a specific educational unit such as a large department, a school, or a school district as a unit of change. Once a unit of change has been determined, it is very important to get the educators in that unit to work together to accomplish the change.

An important part of this is the long-range planning process. There, the key stakeholders are involved in developing a plan and doing some thinking about implementation. This can provide a start on the collegiality and peer support that is needed for long term changes in our educational system. Even if the district does not have a comprehensive long-range plan for computer use, an individual school or even an individual department within a school can develop such a plan. This is a good thing to do and it will help contribute to the successful implementation of the ideas covered in your inservice.

We also know that teachers very much like to observe other teachers performing the desired behavior with students in their regular classrooms (visit other teachers' classrooms, or have other teachers come to their classroom and demonstrate). This is facilitated by having a number of teachers from a school be involved in an inservice. The strong support of a school administrator can also help a lot here.

Q12. I notice that you emphasize discovery-based methods of instruction in your workshops. Why, and how does this relate to effective CII inservice?

The computer is a very powerful aid to problem solving. Problem solving is a higher-order skill, one that involves careful thinking, persistence, taking the initiative, being independent, etc. These are all characteristics that are fostered through discovery-based learning. In my inservice facilitation, I attempt to model the behavior that I want inservice participants to learn.

The CII inservice facilitator is a key educational change agent. Many of the changes that would make education better are not centered around computers. Discovery-based learning provides a good example. Whether or not computers are available to students, discovery-based learning is very important. The CII facilitator thus has the opportunity to simultaneously focus on two key topics—discovery-based learning and computer tools.

This illustrates why it is important that the CII facilitator be an experienced and highly knowledgeable educator. The CII inservice is a vehicle for simultaneously addressing computer issues and a number of other topics related to school improvement.

Q13. Can you give me another example of how you use the time in a CII inservice to teach a non-computer topic?

I think my favorite example is WAIT TIME. The research on wait time strongly suggests that most teachers don't give students enough time to think before calling on some student for a response. Indeed, the typical teacher asks a question to the class and then waits for less than a second before calling on a student volunteer. That isn't enough time for a student to formulate a deep answer. Rather, this type of teacher behavior fosters rote learning of lower-order skills.

The same type of research suggests that the typical teacher almost always calls on a volunteer, but that more and better learning would occur if the teacher would frequently call on some student who has not volunteered.

Thus, in my CII inservices I deliberately provide a long wait time whenever I have the opportunity to do so, and I often call on non volunteers. Also, I openly discuss the need for such a long wait time and calling on non volunteers, and how these actions contribute to developing higher-order skills.

Still another example is provided by cooperative learning. The research literature in support of cooperative learning is very solid. Thus, cooperative learning techniques should be used in CII inservices. Their use and value should be made explicit to CII inservice participants.

Q14. Is it all right to mix elementary school and secondary school teachers in a CII inservice? What about mixing teachers from a broad range of secondary school disciplines?

While this is frequently done, it is most often a mistake. Think for a minute about the basic goal in a CII inservice. It is to have the participant learn to integrate tool use of computers into their classrooms. The classrooms and teaching situations of elementary school teachers are quite different from those of secondary school teachers. The elementary school teacher has a self contained classroom and deals with the same set of students all day, for the entire school year. The secondary school teacher deals with five or six times as many students in a single day, and may see new sets of students at the start of each new semester or trimester. Similarly, a secondary school math teacher's inservice needs are quite a bit different from a secondary school social study teacher's needs. While they both may end up using some of the same software tools, such as a graphics package or a spreadsheet, the types of problems that they want their students to learn how to solve are quite a bit different. Since the inservice should place considerable emphasis on use of computers as an aid to problem solving, and a homogeneous grouping of participants is helpful

Incidentally, this also points out one of the needed qualifications to be an effective inservice facilitator. The inservice facilitator must know and understand the types of problems that the participants are teaching their students how to solve.

The inservice facilitator needs to establish close rapport with participants. The facilitator needs to understand the teaching situations faced by participants and to directly address these teaching situations. A substantial amount of the instruction needs to focus on lesson plans suited to the needs of participants, as well as classroom management, changes in the curriculum, etc., that CII brings about. For these and other reasons it is highly desirable to have homogeneous groups of inservice participants.

Q15. Should the inservice sessions be held in the participants' schools?

The general inservice research literature suggests that it is desirable to conduct inservice sessions in the schools of the participants. This increases the credibility of the inservice and makes it easier for participants to transfer their new knowledge and skills from the inservice setting to their classroom settings. This is particularly true if the school computer lab is similar to that which most of the participants have in their own schools—which would certainly be true if all participants are from one school and the inservice is done in that school.

However, there are many reasons why computer integrated inservice is often conducted at other sites. For example, the nature and amount of computer facility available at school sites may be inadequate and inappropriate for the nature and number of participants. The location of school computer labs might not be as convenient as the location of a district inservice center computer lab. The participants may come from widely varying schools with widely varying computer facilities, so that no school computer lab is representative of the facilities that most of the participants face in their particular schools.

In any event, site selection is important. An inservice should be held in a facility that is conducive to learning. It is easy to give examples of poor facilities. These include facilities that are too cold or too hot, too noisy, have poor seating arrangements, are difficult for teachers to get to, and so on. Most inservice facilitators have themselves participated in a large number of inservices. The inservice facilitator should ask "Would I be happy participating in an inservice in these facilities?"

Q16. How important is it that participants in a CII inservice be volunteers?

At first glance it seems evident that more learning will occur, and that there is increased chance that participants will make use of what they learn, if they are volunteers. The Stecher and Solorzano list of effective inservice practices indicates that having volunteers is desirable.

However, I am not aware of any solid research literature that backs up this position. Moreover, it is difficult to define what one might mean by a "volunteer." For example, suppose that an inservice coordinator for a large school district has just enough resources to offer a particular inservice to teachers in three schools. The inservice coordinator may ask for schools to volunteer. If a principal volunteers a school, does that make the teachers volunteers? Suppose that the requirement is that at least 10 teachers participate from a school. If five teachers initially volunteer and manage to coerce five of their colleagues to volunteer, are the latter five actually volunteers?

The literature on volunteer participation is also mixed because a good inservice can easily change a participant from an unwilling to a willing participant status. Many (most) teachers feel uncomfortable when they are placed in a position of being expected to learn a lot of new material and ideas, and then implement it in their classrooms. But once they make some progress in doing so, most teachers feel quite good about themselves and are motivated to continue their progress.

Q17. **What can you tell me about when to hold an inservice, how long the sessions should be, when to have breaks, how long breaks should be, and so on. Also, what about refreshments, and who provides them?**

To a large extent the answer is "Use common sense." Most inservice facilitators have themselves participated in a large number of inservices. They know what they like, so they know what their fellow teachers like. However, here are a few specific suggestions.

1. No matter what time you schedule an inservice, it will not be the most convenient time for many of the participants. In the needs assessment phase before the inservice begins, you can gather information about times that will be absolutely impossible for potential participants and times that have historically proven acceptable. Don't make the mistake of scheduling an inservice at a very bad time such as the afternoon or evening of the day before end of term grades are due.

2. An inservice session might be as short as an hour or as long as a full day plus evening. To the extent possible, the length of a session should be appropriate to the nature of the content. For example, a one hour session is probably too short for most hands-on inservices. Sessions longer than three hours are too long if the material is vertically structured—that is, if the material builds on material covered earlier in the session. Long inservice sessions need to be broken into a number of shorter activities with frequent changes of pace.

3. Provide three distinct types of breaks:

   a. Change of pace and change of topic breaks. As a rough rule of thumb, these might occur every 15-25 minutes. This type of break may be as short as a few seconds.

   b. Refreshment and rest room breaks. As a rough rule of thumb, these might occur every 1 1/2 - 2 hours and be 15-20 minutes long. They provide time for collegiality, and that is very important.

   c. Lunch/dinner breaks. Time can be saved by bring lunch or dinner into an inservice session. But it is important that the break be long enough to provide a major change of pace (let the brain cells rest a bit) and time for collegiality.

4. Refreshments are very important. Perhaps ideally, a good range of appropriate refreshments would be available as participants arrive, and would continue to be available throughout the inservice session. The nature of appropriate refreshments seems to vary in different parts of the country. However, in addition to coffee with and without caffeine, tea, juices, and soda pop are usually welcome. Fruit, cheese, and crackers are often much to be preferred over donuts and cookies.

If an inservice is to have a sequence of sessions, participants can be organized to provide their own refreshments. Indeed, if the inservice facilitator is clever enough, a competition can be started between various groups of participants, so that refreshments will get better and better as the sequence of inservice sessions progresses.

Q18. Is it necessary to have an assistant when doing a hands-on inservice? How many participants can one inservice facilitator (with no assistants) comfortably handle in a hands-on inservice?

Hands-on inservices are difficult to do. The reason is simple. It is nearly impossible (and probably not desirable) to lockstep a number of participants, keeping all of them exactly in the same place as they examine a piece of software. Even with carefully written directions, in just a few minutes participants will be doing a wide range of different things, many totally unrelated to the set of directions they are supposed to be following. As they run into trouble, they will begin to ask questions. Many of the questions will not easily or appropriately be answered by the statement "Just read and follow your handout." Instead, individual attention must be paid to a number of participants.

A relatively inexperienced inservice facilitator is well advised to limit the number of participants to perhaps 10-12. A very experienced inservice facilitator may be able to handle 20 or more participants in a hands-on workshop. This varies with the facilitator, however, and having that many participants is a considerable strain.

Thus, in most hands-on inservices, the need for one or more assistants is evident. But these do not necessarily have to be paid assistants who are officially serving as assistant facilitators. For example, in most inservices there are some participants who know a great deal about the topics being covered. The thing to do is to learn to make effective use of these people. Since they are experienced teachers, they are generally well qualified to serve as assistants.

Still another important idea is having participants work in pairs or small groups. Cooperative learning is effective, and a hands-on inservice is a good place to model this type of teaching behavior.

Q19. What is the most desirable number of participants per machine in a typical hands-on inservice?

Two people per machine is generally better than having just one or having more than two people per machine. Having two people per machine promotes collegiality, mutual support, help in answering questions, etc., but still provides plenty of work to keep both busy (With three or more people per machine, usually one or more will not be actively engaged.) However, if there are enough machines and some participants want to work alone, generally you should allow them to do so. (In some cases you may be emphasizing paired learning and what it is like to learn in that environment. Then you will insist that all participants work in pairs.)

Try to pair up more experienced users with less experienced users. Let the more experienced users know that they are functioning in a dual role of inservice assistant and participant.

There are dangers in having two people per machine. Sometimes one of the two will strongly dominate and the other will learn little. I suggest that you address this directly. Talk to the participants and make sure that they understand they must be responsible for their own learning. The more experienced computer users must make sure that their partners are learning the material.

Q20. How important is it to have school and district administrative support and participation?

There is a substantial need for support from the school and district administration. Their research on this is solid. The goal in a CII inservice is change in the participants' classrooms. But such change seldom occurs without the explicit backing of the school administration. (This is one reason for doing long-range planning. The planning process requires active participation of administrators. The plan must be approved by top level school administrators and the school board.)

It is very clear that the school administration can play a strong role in fostering change. If a principal participates in an inservice, the principal will be thoroughly familiar with the classroom changes that are being advocated. The principal can then work with teachers to provide needed encouragement, support, and feedback to help them implement the desired change. Some of this may well be built into the evaluation of the teachers.

Q21. Are there major differences between teaching teachers and teaching other students?

Yes. Many successful precollege and college teachers are quite unsuccessful in teaching teachers. It could well be that teachers are the most critical of all potential audiences.

It's not just that teachers are adults, and that teaching adults is different than teaching children. Teachers know a great deal about teaching and learning. They have done a lot of introspection, so they know what will help them learn and what is relevant to their needs. They are busy people, often quite over worked. They recognize that their inservice time is quite valuable and they want this time to be well spent.

Perhaps the key thing that an inservice provider needs to keep in mind is that the goal is to help the participants make changes in their classrooms. Making such changes is both threatening and difficult. The inservice facilitator must do what ever possible to make it "reasonable" that the participants make the desired changes in their classrooms.

Q22. Have you ever heard of "power dressing"? Is this important for an inservice facilitator?

As far as I can tell, the idea of "power dressing" comes from the business world. It has to do with dressing appropriately to fit various business meeting situations. For an inservice facilitator, it is generally desirable to dress as well or a little better than the participants.

The main thing is that one's dressing habits should not distract from the learning process. Of course, there are exceptions. Some inservice facilitators have eccentricities (perhaps carefully cultivated) that are part of the show they put on.

Q23. How should one attempt to deal with obnoxious inservice participants?

Almost every inservice contains one or more participants who seem to have an agenda of showing the facilitator and the other participants how much they know—indeed, that it is only through some mistake that they are not facilitating the

inservice. There are many other types of inappropriate behavior that you will encounter. Some inservice participants insist on talking to each other during presentations, spending their time grading papers of writing letters, wandering in and out of the inservice, etc.

Such behaviors on the parts of the participants are particularly trying to a relatively inexperienced facilitator. Overall, the situation is not too much different from what a new teacher experiences as they begin their teaching careers. There are a few coping strategies that can be taught, and there are many that one acquires through trial and error. What works for one facilitator might not work for another.

One characteristic of the "know it all" is raising detailed questions that are clearly beyond the scope of the materials being covered. The inservice facilitator can acknowledge the question and set a time later during the day when a private meeting will be held to discuss the answer. There should be a clear implication that the question is beyond the scope of the inservice and a strong hint that no further questions of this sort should be raised. However,it is easy to make the mistake of discouraging questions that would be appropriate. Thus, use care in discouraging questions.

An overall lack of professionalism on the part of participants (such as talking, not paying attention, not participating) can be directly addressed. "I notice that some of you are spending your time talking to each other rather than participating in the inservice. I believe this is disturbing other participants, and it disturbs me. I'd be happy to spend some time discussing what is going on. Would one of you be willing to help us work our way through this difficulty?"

Another approach is to say "I notice that some of you are not paying attention, and that you are keyboarding when I have asked you to stop and to pay attention to what I am saying. Each of you knows how you deal with your own students in this type of situation. Please be aware that I don't allow such inappropriate behavior with my students. Don't force me to write your name on the board, keep you in after school, or send you to the principal's office."

The key idea is to openly confront the inappropriate behavior and take advantage of the high level of professionalism that most educators have. Treat them like professionals and make it clear that you expect them to behave as professionals.

Q24. Are there particular difficulties associated with doing an inservice for one's fellow teachers as distinguished from doing an inservice outside of one's own district?

There is a major advantage in doing inservice with your fellow teachers. You know them, the problems they face, and the nature of their work situations. You can design the inservice to pay particular attention to their specific needs. However, you know that you will have to continue to associate with the participants—they are your colleagues. Thus, you need to be very careful to make the inservice quite useful and appropriate to their needs. They will tend to tolerate your inexperience (if your are inexperienced). You can take advantage of your personal contacts and the fact that you are available on a formal or informal basis for follow-up support.

When you do an inservice outside of your own school district, you automatically become an outside expert. You are not expected to have detailed knowledge of the district and its teachers. Instead, you are expected to be more knowledgeable and/or skillful than the participants. You are expected to bring to the inservice ideas and materials that are not readily available within the district.

Q25. What can we do to get the teachers involved who seem unwilling to learn new things or come to our inservices?

All teachers are quite able to learn new things. Computers are not particularly difficult to learn how to use or to use. Certainly all teachers (after all, they are college graduates!) have the necessary intelligence.

Thus, the reasons for not participating are probably deep seated and difficult to address. At one of the scale we have early adopters, and they quickly join any new and exciting movement. By now you have probably reached all such teachers in your school district. At the other end of the scale are the late adopters, and probably the best hope is that they will retire or quit teaching. There is a huge middle group of teachers that can be reached. But this takes time, patience, and considerable effort.

My first suggestion is to initially ignore the teachers who don't seem to want to get involved with computers. Spend your inservice efforts on those that want to be involved. You will experience far greater success, and gradually you will build up a cadre of teachers who can help you to address the needs of teachers who are less quick to change.

There is no magical answer on how to reach the large number of teachers who are somewhat resistant to change. Peer pressure, one-on-one inservice, better incentives, administrative pressure, etc. may all help. As these teachers seem some of their colleagues making routine use of computers, they will gradually become more interested in doing so themselves. As more and more students routinely use computers, this will place pressure on the teachers who resist learning about computers. Given enough time, most teachers will learn to make effective use of computers in their classrooms.

Remember, computers lie at the very heart of some of the changes that are needed to move our schools into the Information Age. Nobody said that it was going to be easy. There will be a continuing need for the type of leadership that good inservice providers are able to be. The computer field will continue to change very rapidly, so the job of the inservice provider will not be accomplished in the next decade or two. Keep at it!

PART 3: EVALUATION

Chapter 3.1
Introduction and Overview

Most inservice projects pay relatively little attention to formative and summative evaluation. Thus, the inservice facilitator often lacks information as to the effectiveness of the inservice or ways to make it more effective. The goals of this section of the book are:

1. To summarize arguments supporting placing significant emphasis on evaluation in the overall process of designing and implementing an inservice program.

2. To provide you with some sample instrumentation and some guidelines for use in doing formative and summative evaluation of an inservice project on computer-as-tool.

There are five key components of evaluation for an inservice project:

1. *Needs Assessment*. Determine the purpose of the inservice. Who is to be served, why, and what are their expectations and needs? A needs assessment for computers in education consists of two rather distinct parts:

   a. A long-range plan for computers in education. The book, *Long-Range Planning for Computers in Schools*, (Moursund and Ricketts, 1988) provides appropriate guidance in developing such a plan. About 1 1/2 chapters from that book are included as part of the Needs Assessment chapter of this book.

   b. Assessment of the specific perceived needs of potential participants in the inservice and the perceived desires of their administrators. The Needs Assessment chapter of this book contains several instruments that can be used for this purpose.

2. *Formative Evaluation*. If the inservice is several sessions long, there will be opportunity for midcourse corrections. The inservice facilitator needs to gather information from the participants about what they are learning (or perceive they are learning) relative to their perceived needs and to the overall goals of the inservice. Such formative evaluation might consist of two relatively distinct components:

   a. A formative evaluation questionnaire, most likely filled out anonymously. Two samples are provided in the Formative Evaluation chapter.

   b. Observations of participant performance during inservice sessions, examination of participant logs of between-session computer use, homework assignments, tests, etc. A successful classroom teacher is quite experienced in gathering and making use of this type of formative evaluation information.

3. *Summative Evaluation Part 1*: Perceived Quality and Effectiveness of the Workshop. The goal is to find out what participants think about the inservice at the time they are just completing the inservice. In this chapter we provide you with several instruments that can be used for this purpose.

4. *Summative Evaluation Part 2*. Residual Effect of the Inservice on the Participants. The goal is to determine the long term effect that the inservice has had on participants. In this chapter we provide you with several instruments that can be used for this purpose. Such instruments might be used several times, such as at the beginning of the inservice, a few weeks or a few months after the inservice, and perhaps a year later.

5. *Summative Evaluation Part 3*. Short Term and Long Term Effect of the Project on the Students of the Participants. The overriding goal of an inservice is to improve the quality of education being received by the students of the participants. However, it is difficult and relatively expensive to make a determination if an inservice is having a significant effect on the students of participants.

This topic is beyond the scope of this book. Evaluation of the impact of inservice requires the careful collection of baseline data and the long term collection of data designed to measure possible changes from the baseline. It is research that typically would be designed and carried out by a professional evaluator rather than the person designing and conducting an inservice.

It should be evident that one could easily spend more time in the evaluation of an inservice program than in the actual preparation and facilitation of the inservice. Except in special situations, such as in a research project, this would be counter productive. As a very rough rule of thumb, the time, effort, and resources put into the evaluation of an inservice project might be ten percent of the total time, effort, and resources going into the inservice project. If a particular inservice is to be used repeatedly, this means that it can be thoroughly evaluated. If it is only going to be used once, this means that it will not be thoroughly evaluated.

Chapter 3.2
Needs Assessment

The first component of a needs assessment is a carefully done, long-range plan for computers in schools. This planning process can take many months and should involve a wide range of the stakeholders—teachers, administrators, parents, etc. A quite minimal plan for a single school may take 50-200 person hours of effort, and developing a district plan may take from 500 hours to many thousands of hours of effort. But research suggests that if a school has a reasonably well thought out plan, it is more apt to make good progress in instructional use of computers than a school that has not undergone the planning process.

Detailed information on how to design and carry out a long-range planning process is given in Moursund and Ricketts (1988): *Long-Range Planning for Computers in Schools*, Information Age Education, 1250 East 29th Place, Eugene, Oregon 97403-1621. The last part of Chapter 1.3 and all of Chapter 1.4 of that book are reproduced here with the permission of the authors.

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Moursund and Ricketts Chapter 1.3: Future

(Only the final part of the chapter is included here.)

Conclusions and Recommendations

Many of the trends discussed in this chapter seem quite clear. The hardware price-to-performance ratio for computers will continue to improve quite rapidly. Hardware will be networked. More and better software will become available. Computers will solve or help solve an increasing range of problems. Artificial intelligence will grow in importance and in use. In summary, our access to information and aids to processing this information will increase many fold in the years to come. Computer use in government, business, industry and education will continue to grow quite rapidly.

We believe the educational implications are profound. The discussion in these first chapters leads us to offer nine general recommendations. Their full implementation would lead to major changes in our instructional system.

Recommendation 1. Computer assisted learning should be viewed as an effective aid to learning productively. There should be considerably increased emphasis on CAL to make broader educational opportunities available to students, to facilitate more individualization of instruction, and to increase learning.

Recommendation 2. Computer-as-tool should be viewed as an efficient aid to students at school, at home, and on the job. All instruction at all levels should take into consideration computers as an aid to problem solving and computers as a source of problems. The use of computer-as-tool should be integrated throughout the curriculum. Curriculum content and testing should be modified adequately to accommodate computer-as-tool.

Recommendation 3. Students should learn enough of the general capabilities, limitations and underlying nature of computers so that the magic of computers is replaced by knowledge and a sense of familiarity. In particular, students should able to act upon the concept of effective procedure (including the creation and representation of procedures, and algorithmic thinking). This concept is among the most important academic ideas of our century. Learning it is part of what it means to be educated for life in our society.

Recommendation 4. All schools should provide good access to computer based information systems. All students should be given instruction in use of such systems and should make regular use of these systems throughout their schooling. The total accumulated knowledge of the human race is growing rapidly. Learning to access and make appropriate use of this collected information is at the core of education.

Recommendation 5. Computer-as-tool should be viewed as an aid to teacher productivity. Every teacher should have access to a personal computer at work and at home. Almost every classroom should have a computer with large display screens or a projector to allow computer aided interaction between teacher and class. All teachers have an increasing need both for general instructional computing literacy and for relatively deep knowledge on uses of computers within their own specific subject areas.

Recommendation 6. All preservice and inservice teachers should be given appropriate opportunities and encouragement to improve their abilities to function well in this changing environment. Computers affect teachers' roles. There is less demand for teachers to be the source of information and the delivery device. There is greater demand to be a facilitator—a role model as students learn "people skills" and higher-order thinking and communication skills. (Recommendations 5 and 6 pose a severe challenge to our entire preservice and inservice teacher education system.)

Recommendation 7. Educators should keep in mind that most real-world problems are interdisciplinary in nature. Schools should place increased emphasis on cross-fertilization among disciplines, on applications of one discipline to the study of a second, and on solving problems making use of information and ideas from several disciplines. The computer can help motivate this change in educational emphasis, and it is a valuable tool in carrying it out.

Recommendation 8. Computers are changing our world view, our metaphors, our ways of dealing with everyday issues and problems. We should be aware of ways computers are changing our world and not lose sight of important underlying values as we adapt. Basic ideas of language, thought, metaphor, and culture should be understood by teachers and taught to students.

Recommendation 9. Open and hidden curricula should change. Those concerned with developing or revising every existing course (or unit) should ask themselves:

- What problems can students solve as a result of learning the content and skills of this course?
- What roles can and should computers play in helping to solve these problems?
- How are and will these uses affect students' lives, and what should the students be doing about these effects?

Neither we nor anyone else can declare in advance how the curricula should change, but this book offers some hints and argues that these changes should be planned for.

These recommendations should contribute to three results fundamental to a successful society in the Information Age. All educators should be, and all students should become:

- Independent, self-motivated, self-sufficient, lifelong learners
- Researchers, able to form and test hypotheses, and to make effective use of the accumulated knowledge of the human race

- Self-confident solvers of problems, well-versed in using their minds and aids such as computers

Improving education with computer support will take a great deal of problem solving, planning, and work. The rest of this book provides information and suggestions that support these efforts.

Moursund and Ricketts Chapter 1.4: Generic Instructional Computing Goals

Executive Summary

The overall long-range planning process begins with an examination of the missions and overall goals of the school system. Computers will contribute to accomplishing these goals, but in many school districts increased use of computers may also lead to some modification of these goals.

A long-range planner also needs to establish visionary goals for computers in education—what roles should computers play in an ideal educational system? These activities lead to establishing goals for computers in education.

Two types of goals are discussed. One is quite specific and is highly dependent on the local situation. For example, a school might set as a goal the integration of desktop publishing into a particular journalism class. The second type is more general and independent of particular school conditions. An example would be to decide that all students will learn to do process writing in a full word processing environment by the time they finish sixth grade. The resulting goals serve as one basis for planning.

Goals and Plans

The recommendations we just offered came from thinking about what education should be doing because computers exist. The goals in this chapter resulted from thinking about what computers should be doing because education exists. These recommendations and goals will be material for your own planning, so an advance organizer may help your subconscious integration processes. The main steps are:

1. Analyze the environment: Gather and analyze data in order to prune curricular deadwood and to develop planning assumptions.

2. Develop a list of agreed-on goals: Create likely goals and choose among them.

3. Write and present the goal-setting plan.

4. Implement: Choose, organize, and work on activities which lead to achieving the adopted goals.

5. Evaluate the situation and feed results from the evaluation into current planning.

As can be seen, the overall process combines both goal setting and implementation. These steps are intertwined. Thus, it's easy to get confused as to which is being worked on. It's also easy to forget that few computer related goals exist in isolation—they're part of a constellation of goals that define students' educations.

School Missions

For this reason, educational goal setting should begin with an understanding of the missions—reasons for existence—of the educational system. There are many books on the foundations and philosophy of education. Any attempt to encapsule such literature will, of course, be incomplete. This brings up a basic point upon which educational planners and their publics must agree. **Except in highly restricted situations, completeness cannot be expected of any stated educational goal or mission. What can be expected is that such a statement can serve as one basis for concerted action to achieve at least one purpose of an educational system.** Planners need to keep in mind why we have schools generally and the basic educational philosophy of their department, grade, school, or district in particular. (As we shall see, this isn't always easy to do.)

We believe every existing public school district and most other educational institutions have, not just one mission, but three semi-distinct missions. All three affect long-range planning. They are:

Life Our school system as an "Institution" has had a long existence and seeks to preserve itself. Our educational system will strongly resist changes that threaten its existence.

Resource A school system is a repository of knowledge and a vehicle for the dissemination of this knowledge. It is knowledgeable educators, libraries, school facilities and pedagogical traditions. A school is a valuable part of the community in which it resides.

Service The bedrock mission: Schools exist to educate students, often in ways other institutions or people don't.

The following short list of student-oriented missions and overall goals is a composite drawn from a survey of the literature and from feedback by educational strategic planners. You will want to modify these statements and add to them to fit your school district or express your personal philosophy of education. We have labeled these statements Mission Statement (MS) 1, 2, etc., so we can easily refer back to them.

This list does not intend to divide education into ten isolated chunks. On the contrary, each mission on this list plays a part in the achieving the other nine missions.

The list has two parts. The Conserving Missions seek to avoid waste and wrongful destruction. So long as the Conserving Missions stay achieved, the Learning Missions underlie good schools' agendas.

CONSERVING MISSIONS

MS1. **Security:** All students are safe from emotional and physical harm.

MS2. **Full Potential:** All students are knowingly working toward achieving and increasing their healthful physical, mental and emotional potentials.

MS3. **Values:** All students respect the traditional values of the family, community, state, nation, and world in which they live.

ACHIEVING MISSIONS

(Capabilities and knowledge tend to increase and maximum attainments will vary.)

MS4. **Basic Information Skills:** All students gain a working knowledge of arithmetic, listening, logic, observing, reading, speaking, storing and retrieving information, and writing.

MS5. **General Education:** All students have appreciation for, knowledge about, and some understanding of:

- History and change.
- Language, culture, and thought.
- Nature.
- Religion, the professed relationships between humans and a deity.
- The positive artistic, intellectual, social, and technical accomplishments of humanity.

MS6. **Lifelong Learning**: All students learn how to learn and have the inquiring attitude plus self-confidence which allows them to pursue life's options.

MS7. **Problem Solving**: All students make use of decision-making and problem-solving skills, including the higher-order cognitive skills of analysis, synthesis, and evaluation.

MS8. **Productive Citizenship**: All students act as informed, productive, and responsible citizens of their country and the world.

MS9. **Social Skills:** All students interact publicly and privately with people younger than themselves, peers and adults in a socially acceptable and positive fashion.

MS10. **Technology:** All students have appropriate knowledge and skills for using our rapidly changing (Information Age) technology as well as relevant technologies developed in earlier ages.

It may be informative to see how well the recommendations in the previous chapter can be matched with these student-oriented missions. The left side of this table is the 10 Mission Statements just discussed. The top of the table are nine recommendations for computer related changes in schools that were listed at the end of the previous chapter and based on the discussion in that chapter and earlier parts of the book. Each 'X" means we think the column recommendation directly supports the row mission. A table like this isn't authoritative, but it can stimulate thought and discussion.

	R1 CAL	R2 CII	R3 ABOUT	R4 CBINF	R5 T.USE	R6 T.ROLE	R7 INTD	R8 EFF	R9 CURR
Security									X
Potential	X	X		X					X
Values								X	X
Basics	X	X	X	X			X	X	X
General Ed	X		X	X			X	X	X
Lf Ln Learner	X	X	X	X			X		X
Prob Solve	X	X	X	X			X	X	X
Prod Citizen		X					X	X	X
Social Skl									X
Technology	X	X	X	X			X	X	X

Note that the teacher-related recommendations (R5 and R6) received no X's. Giving teachers access to computers or teaching them how their roles could change does not, in itself, support any mission directly. If teachers infuse what they have or learn into their classroom practices, any mission might be supported.

It's important to realize that such overriding goals of education are interpreted differently in different school systems. To take an extreme example, in some communities particular religious values (which are part of MS3: Values) play a dominant role, and both the use of technology and instruction about technology may be suppressed. Other communities may value technology greatly (MS10: Technology) and have special, high-tech schools. As school systems are different, so must strategic goals be different.

Sometimes a national edict will play an major role in goal setting. For example, the United States Public Law 94-142 specifies a number of handicapping conditions and educational provisions that must be made for students having these handicapping conditions (MS2). This legislation has led to significant changes in special education in the United States.

Statement of Philosophy

The above list of missions states what we think our educational system should achieve. However, school districts usually want to create and adopt a statement of philosophy. These philosophies can be inspiring and productive when they describe the environment that will simultaneously support many or all of the missions. That is, schools should have certain desired and needed characteristics, or desiderata, if they're to educate their students efficiently and well.

For example, fair but firm discipline will support MS 1-4 and 7-9. Some possible requisites to include in a statement of philosophy are:

- A board and administration that builds teacher participation into decision-making processes
- Challenge in a supportive environment
- Fair but firm discipline
- Individualized programs, individual pacing in particular
- Observation of rights coupled with insistence on responsibilities
- Schools that are comfortable and well-equipped
- Support and participation by the community, the home in particular, in educating each child
- Teachers that, among other things, demonstrate:
  - Appropriate communication skills with groups and individuals
  - Expertise in their content areas
  - Liking for people, children in particular
  - Support for decisions of the district

This list is by no means complete, and we don't necessarily believe that every item in it should be included in every district's philosophy. We do believe that every district's statement of philosophy should be a live document that at least implies how the district intends to achieve its missions.

(Appendix 4.3, "A Code of Ethics for Computer-Using Educators," is also a source for desiderata.)

Overriding Principles for Computer Goal Setting

All the ideas discussed above were common long before computers existed. Such ideas focus on people and societies, rather than on more specific items such as computers and related technology. This suggests two principles to follow when developing computer related goals.

- They should be supportive of and consistent with the adopted overall mission and goals of education.

- They should include additions, deletions, and modifications of the overall mission and goals of education to appropriately reflect computer related technology and the changes such technology is bringing.

More specifically, people setting goals for computers in education should pay particular attention to MS10: Technology. Our educational system is in transition from an Industrial Age system to an Information Age system. Computers are at the heart of the Information Age and are a major change agent.

It's easy to create computer oriented goals that conflict with various interpretations of the student-oriented goals for education. For example, suppose that a school system sets as a goal that the amount of time currently devoted to teaching paper and pencil multiplication and long division of multi-digit numbers should be halved, that all students should be provided with calculators, and that students should be allowed to use calculators for homework and tests.

Such calculator-based proposed changes to the curriculum have proven to be a controversial issue. One can view this as an educational issue (part of MS4: Basic Information Skills), and seek out the opinions of mathematicians and people who regularly use computation. In the United States, the overwhelming response of such people is to support use of calculators. Alternatively, one can view this as a values issue (MS3: Values). On average, both parents and elementary school teachers oppose such a calculator goal. Perhaps parents oppose it because it conflicts with the nature of the education they received. A parent might feel: "When I was in school, we had to do a page of division problems every day. I think it was good for me." Perhaps teachers strongly believe that doing long division by hand is an important part of arithmetic (MS4: Basic Information

Skills) and that they lack math-oriented instructional materials needed to give more emphasis to MS7: Problem Solving.

The calculator example illustrates how computer related technology can affect the curriculum and be a basis for educational change. But education is basically conservative in nature, highly resistant to change. Successful implementation of computer oriented goals requires paying careful attention to the people who will have to change and/or accept the changes.

The second of the two general principles listed in this section suggests that computer educators should aggressively seek changes they feel are warranted by computer technology. To cite an extreme example, what do you think our schools should do as voice input to computers becomes common and inexpensive? Should schools continue to place their current level of emphasis on cursive handwriting? Or should there be decreased emphasis on cursive handwriting, with the time saved being devoted to greater emphasis on process writing in a voice-input computer environment? Most people can talk at least five times as quickly as they can write. (The same general issue exists for keyboarding. Skilled typists can keyboard more than three times as fast as they can hand write.)

Problems of Education

A number of studies and reports, such as "A Nation at Risk," suggest that the American educational system is less than successful in accomplishing its student-oriented mission. This situation can be viewed as a formal problem, so theoretically one could thoroughly describe the existing situation, state a most desirable solution or outcome, delineate the resources and processes available for achieving the solution, and declare a commitment to work toward the solution. (The next chapter calls these four parts of a formal problem the Givens, Goal, Guidelines, and Ownership.) But actually doing that would take a whole hard disk, or more. We'll content ourselves with a brief summary of the problem, calling it a statement of a problem situation.

The United States Educational Problem Situation

1. **Givens**: We have an educational system. For many students this system works well. However, many other students drop out of this system and/or fail to achieve the educational goals that have been set. For example, about 15 - 20 percent of adults are functionally illiterate. In some school districts, fully 50 percent of the students fail to graduate from high school with their matriculating class. (The average for the whole United States is about 25 percent.)

Many students seeking jobs after leaving high school are woefully unprepared for work. Many students entering college find it necessary to take high school-level remedial courses.

2. **Goals**: The student-oriented mission statements given earlier in this chapter summarize some overall student-oriented goals of education. More specific, measurable objectives have been established by state and local school districts. For example, one goal commonly agreed on is functional literacy, which could be defined as the ability to read all sections of a newspaper.

3. **Guidelines**: Local, state or provincial, and national governments annually put a substantial amount of financial resources into our school system. The current educational staff represents a resource that has accrued its training and experience over a period of many years. Other resources include school and community libraries, school buildings and other facilities, supportive parents, colleges of education, etc.

4. **Ownership**: Many government leaders, parents, private citizens, school administrators, students, and teachers feel ownership. They want our country to have a high-quality educational system.

One way for a computer-in-education leader to begin the development of computer-in-education goals is to consider the above problem situation. Within this problem situation the leader can seek

to identify specific problems which computers might help solve or which are related to computer technology.

For example, national assessment provides evidence that many students have relatively poor computational skills. A particular school district might set as a specific goal: Three years from now, the seventh grade students' average score will be above this year's national average on a specific standardized test of arithmetic computational skills. One possible approach to achieving this goal would be to make use of computerized drill and practice materials throughout grades 1-6.

This problem could be approached differently. One could change the grade school math curriculum, perhaps using different books and a different philosophy of mathematics education. One could change the amount of required math homework. One could orient staff development toward the problem. One could provide all students with calculators and allow their use on tests. One could work to convince people that scores on computational tests are unimportant, and that improved scores on problem-solving components of the test should be the goal. (In this latter case, the problem is solved by changing the Goal. See Chapter 2.1.)

This example illustrates a major difficulty in writing a book on long-range planning for computers in schools. Many of the specific problems that can be addressed by use of computers are highly dependent on conditions in particular schools. Details on how to approach these problems must be addressed locally.

Our conclusion is that every school district can benefit by having a cadre of computer knowledgeable staff who are also familiar with the district. These people can view the local educational problems in light of potential uses of computers to help solve these problems. We recommend that every school district have a computer coordinator and that every school have a computer representative or computer coordinator. Appendix 4.1, Computer Coordinators, discusses possible duties and qualifications of such staff. For more detailed information see *The Computer Coordinator*, written by David Moursund and published by the International Society for Technology in Education.

The approach to long-range planning given in this book is necessarily general. Rather than focusing on specific educational problems that computers might help solve, we discuss more general uses of computers in schools. We want to stress that both approaches are important. Educational leaders in a school district have a responsibility to be aware of local problems and how computers might help solve these problems.

Visionary Goals

One approach that can be taken to setting general goals for computers in schools is to think about how computers might help make schools better. What would be the best of all possible educational worlds? What constitutes a high-quality education in an Information Age society? What roles might computers play in moving our educational system in that direction? What is your vision of computers in schools?

It's vital to hold such a vision in your mind when setting long-range goals for computers in schools. Your vision will be one source of your professional drive and integrity. Of course, your visionary goals may be quite different from those of other people. For example, we list the four visionary goals below. How do you feel about them?

1. Education will be completely individualized to best fit the needs of each student. The overall goal is for each student to be both socialized and self-actualized for productive and satisfying citizenship in the Information Age. Expected achievements as a result of schooling might well include:

    - Access to people and technology
    - Capacity to change
    - Conscious goals and philosophy
    - Internalized problem-solving will and skill
    - Information-locating skill
    - Interacting skills with people, nature, and machines

- Joy in learning
- Lifelong learning skills
- Tolerance
- Understanding of the concept that we live in a global village

Educators can model and communicate such achievements. The educational system and the staff are humanistic (very people-oriented) but not acquiescent, and students learn to take responsibility for mastering their material and developing their skills The educational system makes full use of 3 and 4 given below.

2. Educational interactions feature cooperative problem finding and solving much more often than fault finding and imposed decisions. Students often work together to achieve their educational aims. Students receive specific instruction on how and when to act competitively or cooperatively in problem situations.

3. All students have unrestricted access to computers, at school, home, play, and wherever else they might want to have access.

4. The computer systems in 3 give good access to the collected published knowledge and opinions of the human race. This includes CAL materials covering almost all possible course areas and topics that a person might want to study. It includes computer programs designed to help solve the types of problems that computers can help solve. It includes applications software (computer-as-tool) and computer programming languages appropriate to the needs of students.

Notice that these visionary goals are more general and descriptive than prescriptive. (They do, however, support the general student-oriented missions listed earlier.) They are general enough for disinterested discussion during early stages of strategic planning. While they lack the specificity and orientation needed for detailed planning, they suggest topics and attitudes for more specific goals. Notice also that the list in the middle of visionary goal 1 can lead naturally to scenarios or more detailed goals.

Incidentally, much of these visionary goals could have been written a century ago, particularly if one substitutes books or libraries for computers. However, as Chapters 1.1-3 make clear, computers make a pivotal difference.

Each educational leader will have individual ideas for visionary goals. But a brainstorming session will reveal some agreement among the leaders in a particular school community. Lack of complete agreement is useful and instructive, and can lead to fruitful discussions and more realistic planning. For example, do you feel education should be mostly competitive or cooperative? Research strongly supports the contention that students learn more and develop better attitudes in a cooperative learning environment. But most educational systems have a significant orientation toward competition. That is, most educators have been raised in a competitive school environment and accept without question that this is the way schools should be.

General Goals for Computers in Schools

We are now ready to state some general goals for computers in schools. The following list of goals is quite broad, but is grounded in reality. That is, the goals fall between visionary goals and practical, down-to-earth, specific goals to be accomplished during a particular multi-year period. In essence, the list consists of guiding principles or computer-related goals that one works toward over an indeterminate period.

You should keep in mind that the ideas given below represent our opinions. While many computer-in-education leaders support this set of goals, one can find opposition to each of them. This list can serve as a starting point for developing the overriding goals for computers in education in your school district. We have labeled the following list with GG prefixes, standing for "General Goal." Later pieces of this book are tied into the GGs.

GG1: **Computer literacy.** All students shall be functionally computer literate. (Many educational leaders now consider this to be part of MS4: Basic Information Skills.) This functional computer literacy can be divided into two major parts:

a. A relatively broad-based, interdisciplinary, general knowledge of applications, capabilities, limitations, and societal implications of computers to be achieved by the end of the eighth grade. This has three components:

1. Talking and reading knowledge of computers and their effects on our society. (More specifically, every discipline that students study should teach them something about how computers are affecting that specific discipline.)
2. Knowledge of the concept of effective procedure, representation of procedures, roles of procedures in problem solving, and a broad range of examples of the types of procedures that computers can execute.
3. Basic skills in computer input (currently this is keyboarding, but someday the emphasis may be on voice input) and in use of word processing, database, computer graphics, telecommunications, and other general-purpose, multidisciplinary application packages.

b. Deeper knowledge of computers as they relate to the specific disciplines one studies in senior high school. For example, a student taking advanced math courses shall learn about roles of computers in the math being studied. A student taking commercial art courses shall learn about roles of computers in the types of commercial art being studied. Both groups of students shall learn how computers facilitate the artistic presentation of mathematical topics.

GG2: **Computer assisted learning.** Schools shall use computer assisted learning (CAL), when it's pedagogically and economically sound, to increase student learning. CAL includes drill and practice, tutorials, and simulations. It also includes computer managed instruction (see c below). CAL can contribute to MS2-MS10 and of course should not violate MS1.

a. All students shall learn both general ideas of how computers can be used as an aid to learning and specific ideas on how CAL can be useful to them. They shall become experienced users of these ideas. The intent is to focus on learning to learn, being responsible for one's own learning, and being a lifelong learner. Students have their own learning styles, so different types of CAL will fit different students to greater or lesser degrees.

b. In situations in which CAL is a cost-effective and educationally sound aid to student learning or to overall learning opportunities, CAL shall be used if possible. For example, CAL can help some students learn certain types of material significantly faster than conventional instructional techniques can. Such students should have the opportunity to use CAL as one aid to learning. In addition, CAL can be used to provide educational opportunities that might not otherwise be available. A small school can expand its curriculum by delivering some courses largely via CAL.

c. Computer managed instruction (CMI) includes record keeping, diagnostic testing, and prescriptive guides as to what to study and in what order. This type of software is useful to both students and teachers. Students should have the opportunity to track their own progress in school and to see the rationale for work they are doing. CMI can reduce busywork. When CMI is a cost-effective and instructionally sound aid to staff and students, they shall have this aid. CMI can support MS1, MS2, MS4, MS5, and MS10.

GG3: **Computer-as-tool.** The use of computers as a general-purpose aid to problem solving (using word processor, database, graphics, and other general-purpose application packages) shall be integrated throughout the curriculum. (This relates to MS4-MS8 and MS10. Depending on the process used, CII can also facilitate the other four MSs) The idea here is that students should receive specific instruction in each of these tools, probably before completing elementary school. The middle school or junior high school curriculum, as well as the high school curriculum, should assume knowledge of these tools and should include specific additional instruction in their use. Throughout secondary school, students shall be expected to make regular use of these tools, and teachers shall structure their curriculum and assignments to take advantage of and to add to student knowledge of computer-as-tool.

GG4: **Computer related courses.** A high school shall provide both of the following "more advanced" tracks of computer related course work. (These are based on MS7, MS8, and MS10.)

a. Computer related course work preparing a student who will seek employment immediately upon leaving school. For example, if a school has a business curriculum, the curriculum should prepare students for entry-level employment in a computerized business office.
b. Computer science course work (which includes computer programming) designed to give students a college preparation type of solid introduction to the discipline of computer science.

GG5: **Staff support.** The professional staff shall have computers to increase their productivity, to make it easier for them to accomplish their duties, and to support their computer oriented growth. Every school district should provide for staff development, and particular attention should be paid to staff development needed to accomplish GG1-GG4 given above. (This goal supports staff activities needed to effect MS2-MS10.)

This means, for example, that all teachers should be provided with access to computerized data banks, word processors, presentation graphics software, computerized gradebooks, telecommunications packages, and other application software that teachers have found useful in increasing their productivity and job satisfaction. (Computer based communication is becoming a avenue for for teachers to share professional information.) Computer managed instruction (CMI) can help the teacher by providing diagnostic testing and prescription, access to item data banks, and aids to preparing individual educational plans. The use of computers to help prepare IEPs for special education students, now common, provides an example of computer aid for teachers.

GG6: **Long-term commitment.** The school district shall institutionalize computers in schools. Instructional computing shall be integrated into job descriptions, ongoing budgets, planning, staff development, work assignments, etc. The school district shall fully accept that "computers are here to stay" as an integral part of an Information Age school system. (This goal supports MS1-MS10.)

As indicated, each of the GGs can be related to the student-oriented mission statements. Perhaps the best way to summarize this is to point to the last mission statement, MS10: Technology. Students who are currently in school will spend their adult lives in the

Information Age or what comes after the Information Age, with ever-increasing involvement with computer related technology. The GGs form the foundations for moving our schools into the Information Age.

Long-Range Goals Addressing Specific Educational Problems

After proceeding through all of the above types of thinking and goal setting, one still doesn't have specific computer related goals to be prioritized and accomplished during a specific time period. The next step is to set more specific goals.

These specific goals can be divided here into two categories. First, one can develop goals related to solving specific educational problems that exist within one's school district. Most of this section is devoted to providing some samples of goals that a school district or school might set. But such goals are highly dependent on local school situations, leadership, and resources. The setting of specific goals and developing plans to accomplish these goals is essentially the responsibility of educational leaders in individual school districts.

Second, one can develop computer related goals that are relatively independent of any particular school district and that are based on what constitutes an appropriate education for an Information Age society. These can be keyed to the GGs listed above. Every school district's long-range planning should address the topics discussed in Chapters 3.1-3.7 of this book.

A few examples of problem-specific goals are presented and briefly discussed below. Think of these as being designed for a specific (hypothetical) school district. There's no intent that one adopt such a list for one's own school district, since each school district has its own problems that might be addressed by use of computers. Remember, strategic long-range planning requires careful development and prioritization of long-range goals in light of conditions affecting the district.

Sample Specific Computer Related Goals

1. Within three years, all students completing the fifth grade will be able to touch keyboard (the goal will be a minimum speed of 20 words per minute, but exceptional cases will be handled separately), use a word processor, do process writing, and be skilled at both composing and editing at a keyboard. This supports the General Goal GG1-A(3) and many other aspects of instructional use of computers. (The underlying purpose of this goal might be to improve student writing.)

2. Within five years, middle and high school science courses will incorporate computers in laboratory instrumentation. In each course that includes lab work, students will learn to use a computer to gather data, to monitor and (when appropriate) control an experiment, and to help process the resulting data. Computer simulations of science experiments will be used when doing so improves the overall effectiveness of science courses. This supports GG1-B. (The underlying purpose of this goal might be to improve science courses.)

3. Within three years, the high schools will offer a computer based presentation graphics course. The course will have no prerequisite and will be a half-year in length. The course will be geared to students who may desire to make vocational use of presentation graphics upon leaving high school. At least one section will be offered each year, and more sections if there's adequate demand. All students will have access to the graphics presentation software. This supports GG4. (The underlying purpose of this goal might be to modernize one part of the vocational education program.)

4. Within four years, school libraries will be computerized. This means that every bound item and many other major items will be bar coded and entered into one or more computer system(s). The checkout systems will be computerized. Computerized catalogs will replace card catalogs. The union catalog for the entire school district will be computerized and available via a telecommunications system to all schools in the district. This supports GG1,

GG3, and GG6. (The underlying purpose of this goal might be to improve the school district's library system.)

5. Within three years, the high schools will offer a two-year Advanced Placement computer science course. They will offer the sequence at least once every two years, so that all interested students will have the opportunity to take it during their grade 10-11 or 11-12 years. This supports GG4.

6. Within five years, the district will increase line item allocations for instructional computing according to the following table. This supports all of the GGs listed in the previous section, and especially GG6.

Dollars per student, for:	*Hardware*	*Software*	*Materials*
Year 1	$5	$3	$0.20
Year 2	$8	$5	$0.30
Year 3	$11	$7	$0.50
Year 4	$13	$8	$0.50
Year 5	$15	$9	$0.50

7. Within two years, the district will catalog all computer software currently owned by the school district and/or each individual school and arrange with the schools for its appropriate storage and accessibility. A mechanism will be established so that schools can borrow software from each other. This supports a number of the GGs listed in the previous section.

8. Beginning immediately, schools will allow teachers to check out computer systems and software for the summer. Before the next school year, the district will place two computers in the teacher's lounge of each school. This supports GG5.

9. During the next year, the district electronics repair shop will gear up to do preventative maintenance and board-swap repair of the types of computer equipment we currently use in this district. This supports all of the GGs.

10. Each year during the next two years, the district will offer the staff at least one course like "Introduction to Computers in Education" and one like "Advanced Topics—Computer Applications in Education." Both courses will concentrate on integration of computers as a general-purpose tool in the curriculum. This supports GG5.

11. During the next year, each elementary principal will identify a computer coordinator/computer committee representative for the school. Each of these people will receive five days of training during a special leadership development workshop to be given the following summer. The proposed budget for the year after next will contain a yearly payment of $500 for each elementary school computer coordinator, and these coordinators will have reduced obligations for non-instructional work such as supervising lunch rooms and organizing extracurricular school activities. This supports a number of the GGs, especially GG2, GG3 and GG5.

12. Beginning next fall, all students in grades 3-5 shall use computerized drill and practice in arithmetic for 10 minutes a day. The following summer, the School Board will receive a summary and description of results and hear recommendations regarding computerized drill and practice. This supports GG2.

13. Next year, participants in the fall inservice day staff development program shall be able to have computers at least three times during problem-solving activities in their classrooms. This supports GG3.

The above specific goals have the form "By **when**, **who** will achieve **what**." Chapter 2.4. advocates use of this form and refers to such statements as objectives. Dozens of additional objectives could be added to this list. The development of such lists is an essential part of strategic planning. Often such a list of goals is developed through brainstorming sessions, perhaps in a multi-day retreat.

Notice how we've tied each sample objective to one or more GGs. Since the GGs can be tied to the mission and overall goals of education, we've created a chain of logic that can be used to justify or "sell" the goals. But we haven't tied each objective to a specific local problem. Only people who live with the problem can do this.

For example, the *first objective* discussed above is to teach elementary school students keyboarding and process writing in a word processing environment. The local problem may be that student writing is unsatisfactory and that not enough emphasis is placed on writing. The school district setting this goal may be convinced that it represents a cost-effective solution to improving student writing skills.

The *second objective* concerns use of computers in science labs. The specific problem might be that the science labs have become somewhat out-of-date, and the school district desires to bring these labs into the Information Age.

The *third objective* is to offer an computer based presentation graphics course. One specific problem being addressed might be to prepare students for full- or part-time jobs in modern small businesses.

The examples above indicate that there are two important approaches to justifying goals for computers in education:

- Appeal to a general mission statement for education and to some general goals (GGs) for computers in education. Computers support one or more mission(s).

- Demonstrate how specific computer-in-education goals address specific problems in the district. Computers will help overcome a difficulty.

These approaches are not mutually exclusive. Ideally, planners will be able to use more than one approach when seeking support for a goal.

When goals are discussed, it may also become evident that adoption of the goal will augment the district's resources or make things generally better. These results are welcome and may be quite significant, but the two approaches above are critical when presenting non-trivial plans to decision makers.

References

National Assessment of Educational Progress. *A Framework for Assessing Computer Competence: Defining Objectives*, Educational Testing Service, 1986.

Reich, Robert B. "Teaching to Win in the New Economy," *Technology Review*, August/September 1988, pp. 24-25.
(Urges schools to graduate students who are literate, numerate, problem devisers, and problem solvers who thrive on responsibility and collaboration.)

Resnick, Lauren B. "Learning In School and Out (the 1987 Presidential Address)," Educational Researcher, December 1987, pp. 13-20.
(This article repays reading and rereading. Her research continues.)

Ricketts, Dick (Project Director). *Course Goals in Computer Education, K-12* (rev. ed.), 1985. (This work contains nearly 1,000 organized course goals related to computers and their impacts. For more information, contact Director of Instructional Services, Multnomah Education Service District, P. O. Box 16657, Portland, OR 97216. Collections for thirteen disciplines exist.)

Sweeney, Jim. *Tips For Improving School Climate*. American Association of School Administrators (1801 North Moore Street, Arlington, VA 22209-9988), 1988.
Ten essentials to a winning school climate are:

1. Achievement
2. A sense of family
3. A supportive, stimulating environment
4. Closeness to parents and community
5. Communication
6. Feedback
7. Positive expectations
8. Rewards
9. Student-centered thinking—What's best for the kids, individually and collectively?
10. Trust

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This is the end of material from the Moursund and Ricketts book.

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A second component of Needs Assessment is determining the detailed needs of potential participants. That can be done by survey questionnaires, informal discussions, and interviews. Several forms that might be used for this purpose are given on the following pages. These were developed for use in the NSF project TEI 8550588 and field tested during 1985-88. Professor Dick Rankin was the project evaluator and contributed substantially to the development of the instrumentation given in the remainder of this part of the book.

Research strongly suggests that the school principal is a key change agent in the elementary school. At the secondary school level one or more of the administrators are key change agents. If teachers are to change, it is most helpful if they have the encouragement and support of their administration. It is quite desirable to have the administrators participate in the inservice alongside of the teachers. In any event, it is helpful to the inservice facilitator to have knowledge of what the school administrators know about computer use in their school, and their attitude toward computer use. This information might be gained through use of the Principal Interview Form given on the next page.

Principal Interview Form (Needs Assessment)

Name: _____

School: _____

Date: _____

Principal interviews are conducted as part of the needs assessment. The idea is to interview the principals (or other high level school administrators) in the schools of the inservice participants. Ideally, the people being interviewed would also participate in all of the inservice sessions, or at least in a significant number of them. Research suggests that this is highly desirable if the intent is that the inservices will lead to changes in the classroom. School administrators are key educational change agents. Unless they give open and strong support to teachers working to make change in the curriculum, relatively little change is apt to occur.

One typically begins an interview by explaining its purpose and what the information will be used for. The person being interviewed should be assured that the information will be confidential. Some people doing interviewing find it desirable to use a tape recorder. If this is done, be sure to ask the interviewee if he/she minds being recorded. Since direct quotes of the answers are not needed and many people feel uncomfortable talking into a recorder, it is probably better to not make use of a recorder.

When several people are to be interviewed for the same purpose, it is helpful to have a script or a sequence of questions that all will be asked. However, feel free to deviate from the script in order to follow up on important issues.

1. What do you perceive are the most pressing needs related to the use of computers in your school? (*Note*: Presumably the interviewee knows that your orientation is toward instructional uses of computers. However, you might find that the answer provided is oriented toward administrative uses. If so, you might want to try this question again, but emphasizing instructional uses.)

2. Please describe the role and duties of the computer coordinator or computer building representative at your school. (If there is no such person, probe to find the name of the person who tends to do the most in helping the school make instructional use of computers.)

3. Please describe some of the instructional uses of computers currently occurring at your school.

4. What computer equipment is available for use by students and teachers at your school? How is it situated?

5. What training has your staff had in the use of computers? What training have you had?

6. Does your school have a written set of long-range plans for instructional use of computers? (If yes, can you provide me with a copy?)

7. Does your school district have a written set of long-range plans for instructional use of computers. (If yes, can you briefly describe the plans?)

8. Are there other important things I should know about instructional use of computers in your school that would be helpful in designing and conducting inservice for your teachers?

School Site Information Sheet (Needs Assessment)

(*Note*: It is often quite desirable to hold inservice sessions in the schools of the participants. This form is designed to aid in collection of information about the computer facilities available in a school that might be available for inservice sessions and/or that might be available to inservice participants for their personal use and use with their students.)

Site _____ Contact Person _____

Which equipment is available? _____

_____

When is equipment available? _____

_____

Where is equipment available? _____

_____

What is the procedure for organizing or obtaining equipment for use in the classroom?

_____

What is the procedure for securing use of the lab? _____

_____

What software is available? _____

_____

_____

How is it obtained? _____

_____

Time schedule? (Obtain a copy of the school and its teachers' time schedule.)

Participant Information (Needs Assessment)

Name: _____

School: _____

Note: This instrument is designed to be filled out by educators who might be interested in participating in a computer inservice. One way to make use of this instrument is to meet with the teachers in a school who have expressed some interest in an inservice. Discuss the nature of the types of inservices that might be possible. Answer their questions. Then have each person who might be interested in participating in an inservice fill out the following form. Assure the teachers that the results will be confidential.

This form is relatively similar to one of the forms given in Chapter 3.4 Summative Evaluation: Residual Effect of the Inservice on the Participants. Summative evaluation requires that one have baseline data to compare against. Often it is best to gather that baseline data before the beginning of the inservice, or very early in the inservice.

Instructions:
For numbers **1-5** below, please **circle** yes or no.

1. Have you requested that your school or department purchase any software within the last year?

   YES NO

2. Have you used the school district's software preview center within the past 12 months?

   YES NO

3. Does the integration of the computer in education change the priorities of what should be taught in the curriculum?

   YES NO

4. Do you plan to purchase a personal computer within the next 12 months?

   YES NO

5. Do you have a computer in your home? YES NO

   If you circled **YES**,

   (a) What brand and model is it?

   (b) Do you bring it into the classroom? YES NO

Instructions:
For numbers 6-14 below, please write a **brief** answer.

6. List the **subject areas** in your curriculum where you think computer use currently benefits **your students**. (Give specific examples of major topics or particular courses that you teach.)

7. List the **computer applications** you think currently benefits **your students**.

8. List the **subject areas** in your curriculum where you think computer use currently **benefits you**.

9. List the **computer applications** you think currently **benefit you**.

10. List the areas (not necessarily in your classroom) where you might use a computer (ie., any kind of personal use, recreation, database, gradebook, etc.).

11. List the **names** of the computer programs/packages (titles) you have ordered or requested to be ordered for educational/school use in the last year.

12. List the **names** of the top five computer programs/packages (titles) that you use or have used most frequently with your students.

13. (a) List the **names** of the top five computer programs/packages (titles) that you use in your role as an educator or for personal use.

(b) Indicate the **approximate number** of computer programs/packages you use with your classes. _____

(c) Indicate the **approximate number** of computer programs/packages that you use for personal use. _____

14. What kind of inservice or workshops would you like to see in the future? What characteristics and content would they have to have so that you would probably participate on a voluntary basis?

Chapter 3.3
Formative Evaluation

Formative evaluation is designed to gather information during an inservice to allow midcourse corrections. Much of this may be done in an informal fashion, for example through observation of participants during the inservice sessions, by talking with participants during breaks, and by paying careful attention to the types of questions participants ask during the inservice sessions.

However, if an inservice extends over a number of sessions, it is desirable and quite useful to do a formal formative evaluation. A sample instrument for doing this is discussed in the next section. It was designed specifically for an inservice to introduce secondary school science teachers to use of computer-as-tool. However, it can easily be modified to fit other computer inservices. A sample of such a modification, designed to fit a social studies inservice, is provided later in this chapter.

The material which follows was written for use in the NSF project TEI 8550588. It was first published in *Computer Integrated Instruction Inservice Notebook: Secondary School Mathematics*, published by ISTE.

Questionnaire specifications: The instrument given in Table 1 was used to evaluate a computer workshop designed for a mixed audience of absolutely novice and more experienced users of computers. All were middle school and high school science teachers. The main long term goal of the workshop was to increase the use of computer as a tool in the science classes taught by the participants.

The goals of the questionnaire were to evaluate the technical quality of the delivery, the specific action of some of the components, and whether the participants were able to see the major goal of the workshop. You may want to skim-read the questionnaire, and then come back to this discussion. The small letter m beneath the response rows was the mean response of participants in one particular workshop.

There were a few questions aimed at specific problems such as the effect of computer labs on instruction and the problems that participants may have had shifting to an unfamiliar computer. (While a number of participants had encountered the Macintosh before, relatively few had substantial experience with this machine.)

Questions 1, 7, 14, 15, 16, 18, 20, 22, and 25 are directed to the delivery of the workshop. Question 25, I would recommend this workshop session for other teachers, is particularly important. If the responses to these questions were negative, then there would have been the need for extensive soul searching and a change in direction.

Questions 4, 8, 10, 11, and to some extent 9 are directed to the type of programs being presented in the first half of the workshop. In these sessions the general presentations covered using the computer and databases. This was what was being taught, it was not negotiable. Negative responses to these questions would have led to a rethinking of the delivery system, not a re-emphasis on other materials.

Question 2 and 4, are directed at the general idea of the workshop. These questions were covered more thoroughly in the evaluation at the end of the workshop.

Question 23, 24, 27, and 29, were directed to some problems revolving around transferring from Apple to Macintosh computers. Question 26 was very specific because the evaluator noticed that some of the participants seemed to be having difficulty with the mechanics of typing.

In summary: We expect to ask questions focused at the content of the workshop. We expect to take a very brief look at the effectiveness of the delivery systems which include the quality of the teaching and the programs demonstrated.

Results: Table 1 presents the evaluation instrument and sample data collected about halfway through an eight session inservice. The relevant information to examine is the median responses to each of the items 1-25. It is well not to overwhelm the user of the data with statistical excesses from packaged programs. The inservice facilitator may be able to modify the inservice sessions in response to major deviations from what was anticipated. Medians, rounded to the nearest .5, suffice for this purpose. Of course, some inservice facilitators will want to see more detailed statistics. We have not included additional statistical data here, but the evaluator of the project provided as much detail as the facilitators desired.

Output in the form of Table 1 contains information that is very helpful. In particular, question 3 reveals that participants see the ability to use computers more in the future as being enhanced. It is quite apparent that the overall evaluation of this workshop is good. The participants feel more confident with computer (Q1), find the material worthwhile (Q14), and see the workshop as relevant. Some of the texture of the situational setting can be found in the participants responses to the questions about availability of computers (Q21 and Q13). Those delivering the workshop should be proud of the responses to Q14, the binder and handout materials are useful; Q16, the workshop lived up to my expectations; and Q25, I would recommend this workshop to others. Responses to all these questions are near the top of the scale.

There are worries; Q2 indicates that they are not using the computer more. Q9 and Q11 indicate that more time should be spent on why databases are needed and the game of the week.

It is important to remember why this particular workshop was selected for illustration. It was the first time the science inservice was offered to a group of teachers, and it was the first time the inservice facilitator was in charge of such an extensive inservice series of sessions. Different computers were used (that is, Macintosh computers instead of the Apple 2 computers that the participants might have anticipated). The second presentation of the material (that is, a replication of the inservice series done the next year) showed that the providers made some changes that were reflected in the participants responses. The evaluator does not recommend cross groups comparisons because conditions and clients are not constant.

Science Inservice Evaluation Instrument (*This is Table 1*)

(*Note*: This instrument was designed to require about 20 minutes to complete. The small letter "m" in the response field indicates the Mean Response of a group of science teachers who were participating in a sequence of eight two-hour computer inservices.)

Instructions: Please take about 20 minutes of your time to fill out the form. It is designed to help us assess the quality and effectiveness of the inservice, and to improve it. All responses will be confidential. Only summary statistical data and responses that cannot be used to identify specific participants will be provided to the inservice facilitator.

A response of 1 indicates that you strongly disagree with the statement, a response of 5 indicates that you strongly agree with the statement, and a response of 3 is neutral.

		Disagree				Agree
1.	I feel more competent with computers than I did at the start of this workshop.	1	2	3	4 m	5
2.	I am using computers more with my students than I did at the start of the workshop.	1	2 m	3	4	5
3.	As a result of this workshop, in the future I will be able to use computers more with my students.	1	2	3	4 m	5
4.	I can see ways to integrate the programs demonstrated in the workshop into my curriculum.	1	2	3	4 m	5
5.	As a result of this workshop, I have found programs not demonstrated in the workshop and integrated them into my curriculum.	1	2 m	3	4	5
6.	I have been able to interest other teachers in what we have been doing in these workshops.	1	2	3 m	4	5
7.	The sessions contain too much information to absorb comfortably.	1	2 m	3	4	5
8.	I would like to see some programs demonstrated that are directly related to science.	1	2	3	4 m	5
9.	The Game of the Week has been helpful.	1	2 m	3	4	5
10.	The sessions have helped me recognize non computerized database applications in my classroom.	1	2	3	4 m	5
11.	I feel that databases have a legitimate role in science classrooms.	1	2 m	3	4	5
12.	Time should be spent exploring practical problems like getting students to the computers.	1	2	3 m	4	5

		Disagree				Agree
13.	The greatest block to using computers is lack of access.	1	2	3 m	4	5
14.	The contents of the binder (the handouts) is worthwhile.	1	2	3	4 m	5
15.	The workshop activities are relevant to my current classroom needs.	1	2	3	4 m	5
16.	This workshop has lived up to my expectations.	1	2	3	4 m	5
17.	I have learned a great deal about computers from other participants in the inservice.	1	2	3 m	4	5
18.	We should take more time to explore the programs that we have seen in the workshops.	1	2 m	3	4	5
19.	The instructors should have spent more time assessing existing computers skills in the group of participants.	1	2 m	3	4	5
20.	The written materials clearly explain the software that we are using during the workshop sessions.	1	2	3	4	5 m
21.	The district emphasis on computer laboratories for word processing limits access to computers at those times I might use them for science.	1	2	3	4 m	5
22.	The progress of the workshop through the computer programs we have explored is slower than I would have liked.	1	2 m	3	4	5
23.	Transfer (of my previous computer knowledge) from other computers to the Macintosh was relatively easy for me.	1	2	3 m	4	5
24.	Learning the mechanics of using the computer is more the responsibility of the individual teacher (via working outside of the workshop) than it is of the workshop facilitators during workshop sessions.	1	2	3	4 m	5
25.	I would recommend this workshop for others.	1	2	3	4	5 m

Instructions: The following four questions can be answered Yes or No. Please circle your choice.

(*Note to reader*: The percentages given are data from the same group as above.)

26.	I am a reasonably competent touch typist.	Yes 67%	No 33%
27.	I was familiar with the Macintosh computer before the start of the workshop.	Yes 42%	No 58%
28.	The bulk of the material we have covered was familiar to me before the start of the workshop.	Yes 25%	No 75%
29.	I was familiar with the *Apple II* computer or other computers before the start of the workshops.	Yes 67%	No 33%

Instructions: Please provide brief responses to the following questions. Use the back of the page if necessary.

30. What is the most positive aspect of the workshop?

31. What are the factors most needing improving?

32. Please write up three ideas that you think you have picked up that may be directly applicable to your classes.

33. Any other comments you would like to make would be appreciated.

Table 1: Science Inservice Evaluation Instrument

Social Studies Inservice Evaluation Instrument

Note: The form given below is quite similar to the Table 1 form used with science teachers. It illustrates how to adapt that form to other groups of teachers. The sample form provided here was designed for use in an inservice for secondary school social studies teachers.

Participants should be assured that their answers will be kept confidential and will have no bearing on their grade in the inservice, if grades or other requirements have been established for satisfactory completion of the inservice. It is desirable that this form be administered by someone other than the inservice facilitator and that the results be compiled by someone other than the inservice facilitator. The inservice facilitator should only receive summary statistical data and participant comments that cannot be associated with specific participants.

We are interested in your overall evaluation of this workshop. For numbers 1 - 34, please circle the number that best describes your attitude. If you agree with the statement circle 5 for agree. If you disagree with the statement circle 1. Circle 3 if your attitude toward the statement is neutral.

		Disagree				Agree
1.	I feel more competent with computers than I did at the start of this workshop.	1	2	3	4	5
2.	My students have increased their classroom use of computers as a result of this workshop.	1	2	3	4	5
3.	Lack of student access to computers is the greatest block to my integrating computers into the curriculum.	1	2	3	4	5
4.	I feel competent integrating the software programs and activities demonstrated in the workshop into my teaching.	1	2	3	4	5
5.	I have sought out and located software programs not demonstrated in the workshop and integrated them into my curriculum.	1	2	3	4	5
6.	I have been able to interest other teachers in what we have been doing in these workshops.	1	2	3	4	5
7.	Too much information was presented during the sessions to absorb comfortably.	1	2	3	4	5
8.	I would like to see the workshop demonstrate software programs and activities more directly related to my content area.	1	2	3	4	5
9.	Time should be spent exploring practical problems like getting students to the computers.	1	2	3	4	5

		Disagree				Agree
10.	As a result of this workshop I will increase my instructional use of computers with my students.	1	2	3	4	5
11.	The contents of the participant notebook and handouts will be useful in planning and developing computer related activities for my classes.	1	2	3	4	5
12.	I have started collecting computer software disks.	1	2	3	4	5
13.	This workshop has lived up to my expectations.	1	2	3	4	5
14.	I have learned a great deal about computers from other participants in the workshop.	1	2	3	4	5
15.	More time should have been set aside for participants to explore the software programs and materials demonstrated during the workshop.	1	2	3	4	5
16.	The written materials clearly explain how to move through the programs.	1	2	3	4	5
17.	The progress of the workshop is slower than I would have liked.	1	2	3	4	5
18.	The information presented in the sessions is relevant to my classroom.	1	2	3	4	5
19.	I would recommend this workshop to other teachers.	1	2	3	4	5
20.	I am not convinced that computers will increase student achievement in my content area.	1	2	3	4	5
21.	I now talk more to other teachers about computers than I did at the start of the workshop.	1	2	3	4	5
22.	Money for computers should be shifted from other areas of the school budget.	1	2	3	4	5
23.	The instructors should have spent more time demonstrating a greater variety of software.	1	2	3	4	5
24.	The greatest block to my using computers in the classroom is my philosophical disagreement with their worth in my content area.	1	2	3	4	5
25.	The progress of the workshop is faster than I would have liked.	1	2	3	4	5

		Disagree				Agree
26.	Lack of teacher access to computers is the greatest block to my using computers.	1	2	3	4	5
27.	I would like a workshop leader to come into my classroom and demonstrate a lesson using the computer as an instructional tool.	1	2	3	4	5
28.	I feel more comfortable using computers with my students than I did at the start of the workshop.	1	2	3	4	5
29.	I am willing to have someone come into my classroom and observe me using computers with my students.	1	2	3	4	5
30.	I am more inclined to let students use computers to develop an understanding of concepts and ideas than I was at the start of the workshop.	1	2	3	4	5
31.	I would have liked time during the workshop to modify and/or develop computer activities for use in my classroom.	1	2	3	4	5
32.	I would prefer that all workshop participants be teaching the same courses and grade levels.	1	2	3	4	5
33.	I found it easy to get access to computer hardware and software between sessions to try out ideas we learned in the workshop.	1	2	3	4	5
34.	I would be more likely to use computers if there was a computer resource person I could consult with at my school.	1	2	3	4	5

For Questions 35 - 40 circle, please circle yes if you agree with the statement and no if you disagree with the statement.

35.	I have spent more time watching others use the computers in the workshop than I have spent in using them myself.	Yes	No
36.	The goal of this workshop should be developing teacher skills in the practical use of the computer.	Yes	No
37.	I felt pressure to attend this workshop from other sources.	Yes	No
38.	I would rather spend more time with the computers and less time concerning ourselves with issues such as other resources in the school.	Yes	No

39. The goal of this workshop should be developing an understanding of how to integrate computers into my content area. Yes No

40. I have increased my understanding of how to use computers as a problem solving tool as a result of this workshop. Yes No

For numbers 41 - 48 please circle the number the best describes your attitude toward each of the software programs listed. If you think the program was excellent circle 5 for excellent. If you think the program was poor circle 1. Circle 3 if your attitude toward the program is neutral. Please do not refer to your handouts or notebook; we are interested in how you remember these software programs.

	Poor				Excellent
41. United States Database	1	2	3	4	5
42. North American Database	1	2	3	4	5
43. President Elect	1	2	3	4	5
44. The Other Side	1	2	3	4	5
45. U.S. History	1	2	3	4	5
46. Easy Graph	1	2	3	4	5
47. MECC Graph	1	2	3	4	5
48. Bank Street File	1	2	3	4	5

Please write brief answers to the following questions.

1. Has the workshop been relevant to your needs?

2. Has the workshop been organized in a way that facilitated learning? If not, how can we improve it?

3. Please write a short description (2 or 3 sentences) of what you perceive as the purpose of the workshop.

4. Identify the most positive aspect(s) of the workshop.

5. Please describe two or three ideas demonstrated during the workshop that are directly applicable to your classes.

6. What can we do to improve this workshop and others like it?

7. Please feel free to make any general comments about the inservice.

Table 2: Social Studies Inservice Evaluation Instrument

Participant Log Sheet

Note: It is common to request participants to keep a daily log of their computer use and related activities during the weeks of the inservice sessions. These are to be turned in each week; they may provide the inservice facilitator with valuable formative evaluation information. Some facilitators will use logs only for formative evaluation of the inservice series, while others may also use them in evaluating individual participants. In the latter case, the facilitator should expect that some of what is written on the log sheets was written to fit the perceived needs of the facilitator.

Name _____ Date _____

Please use this form to record **all** of your computer related activities, both at school and at home, during the week. This log sheet is not used for grading purposes. Its purpose is to provide formative evaluation information to the inservice facilitator.

Monday

Tuesday

Wednesday

Thursday

Friday

Weekend

Use back of sheet for notes, additional comments, and questions you would like to ask the inservice facilitator.

Chapter 3.4
Summative Evaluation:
Perceived Quality and Effectiveness of the Workshop

This section contains five forms that can be used to evaluate perceived quality and effectiveness of the workshop. The first gathers Demographic Information. It might be used before the first inservice session, or during the first inservice session. The second might be used at the beginning and end of a one-shot inservice or a sequence of inservices. The remaining three are designed for use at the end of an inservice. All five forms have been adapted from forms developed by Professor Phil Browning of the University of Oregon.

Training Program Evaluation

(This form is based on the work in Philip Browning's *The Impact of Nationwide Training Programs to Promote Self-Advocacy*, and revised with permission of the author. Philip Browning is a professor in the College of Education at the University of Oregon, Eugene, Oregon 97403.)

Identifying Information

Name: _____

Address: _____

_____

Home Phone _____ Work Phone _____

Age _____ Sex _____ Highest Degree _____

Employment Status (check one)

Full Time _____ Part Time _____ Volunteer _____

Employer: _____

Job Title: _____

Major Job Duties: _____

Number of Years of Work Experience: _____

Participant Objectives

We are interested in why you are participating in this workshop. Please state as briefly and specifically as possible what you would like to gain from this workshop. At the end of the workshop you will be asked to indicate how well each of your objectives was met.

	Objective	Unmet			Met
1.	_____	1	2	3	4
	_____				
	_____				
2.	_____	1	2	3	4
	_____				
	_____				
3.	_____	1	2	3	4
	_____				
	_____				
4.	_____	1	2	3	4
	_____				
	_____				

Workshop Facilitator Objectives

We are interested in how well you think each of the following objectives of this workshop was met. These are the objectives used in the overall design of the workshop.

Objective	Unmet			Met
1. Participants have increased knowledge on how to design and conduct staff development for integration of computer-as-tool into the curriculum.	1	2	3	4
2. Participants have increased knowledge and understanding of roles of computers in problem solving.	1	2	3	4
3. Participants have increased knowledge and understanding of long-range planning for computers in schools.	1	2	3	4
4. Participants have increased ability to use discovery-based and group discussion techniques in the workshops they conduct.	1	2	3	4
5. Participants had fun.	1	2	3	4

Overall Program

We are interested in learning how you perceived the "overall" workshop in terms of the content, presentations, and presenters. Please rate each of the areas below.

Content	**Low**			**High**
New	1	2	3	4
Relevant	1	2	3	4
Practical	1	2	3	4

Presentations	**Low**			**High**
Clear Objectives	1	2	3	4
Organized	1	2	3	4
Involving	1	2	3	4

Presenter(s)	**Low**			**High**
Informed	1	2	3	4
Articulate	1	2	3	4
Well Prepared	1	2	3	4

Comments:

Participant Change

We are interested in learning what changes have occurred for you as a result of this workshop. Please rate your perceived degree of change in each of the four types of change.

Type of Change	Low Degree of change			High Degree of change
Informational (gain in knowledge, understanding, awareness)	1	2	3	4
Behavioral (gain in skills, ability to apply information)	1	2	3	4
Attitudinal (change in beliefs, perceptions, values)	1	2	3	4
Motivational (increased drive, desire, incentive)	1	2	3	4

Comments: Please discuss other job-related changes that you attribute to this workshop.

Chapter 3.5
Summative Evaluation: Participant Change

Remember, the overriding purpose of the inservice is to improve the quality of education being received by students. Thus, we want and expect that inservice participants will change their classroom behavior to reflect ideas and content presented and practiced during the inservice sessions. In this chapter we briefly discuss some ways to obtain information about participant change. Some of the instrumentation given in this chapter was developed by Vivian Johnson as part of her Ph.D. dissertation research in evaluating the NSF project TEI 8550588 inservice sessions.

We know from extensive research that one-shot inservices produce little or no change in the vast majority of teachers. Of course, there are sometimes a few exceptions. A few percent of any large group of teachers will be early adopters. They will be quick to seize on new ideas and try them out in their classrooms. They may make major changes in their classroom behavior based on a modest amount of inservice.

As far as the field of use of computer-as-tool in the classroom is concerned, the early adopters may well have gotten started years ago. They are most likely the ones that are now organizing and conducting inservice sessions. The participants in a current typical computer inservice currently are not the early adopters. If the goal of the inservice is to produce change in the classroom behavior of these teachers, a sequence of inservices and other support will be needed, and this must extend over a long period of time.

Relatively few inservice projects track participants after the inservice ends. They do not attempt to see if participants are implementing the ideas and content from the inservice sessions. There are many reasons for this. Most common, of course, is time and money. The inservice facilitator may not have the time and money to do such follow up summative evaluation. Another common factor is that teachers do not like to be evaluated.

Because teachers do not like to be evaluated, the summative evaluation being discussed here should be done discretely, in a non threatening manner. Remember, the goal is to determine the effectiveness of the inservice. Data collected should remain confidential. The data should not be used to evaluate the workshop participants. (The goal is to evaluate the workshop, not the workshop participants!)

The forms provided here might be used weeks, months, or even a couple of years after the end of the inservice sessions.

Computer Attitudes Survey

Name: _____

School: _____

(*Note*: It is relatively common to administer an attitude scale before and after an inservice, and perhaps a third time for long term follow-up. This is done as part of the summary evaluation of an inservice. As for all collections of evaluative information, participants should be reassured that the information collected will be confidential and will not affect their grade in the inservice. Ideally, this survey form would be administered, collected, and analyzed by someone other than the inservice facilitator.)

Instructions:
Please circle the number that best describes your attitude. If you strongly agree with the statement circle 1 for strongly agree. If you strongly disagree with the statement circle 5. Circle 3 if your attitude toward the statement is neutral.

		Strongly Agree				Strongly Disagree
1.	Computers can improve learning of higher order skills.	1	2	3	4	5
2.	Computers will improve education.	1	2	3	4	5
3.	Computers can improve drill and practice.	1	2	3	4	5
4.	Computers will create jobs needing specialized training.	1	2	3	4	5
5.	Computers will improve health care.	1	2	3	4	5
6.	A person today cannot escape the influence of computers.	1	2	3	4	5
7.	Computers will displace teachers.	1	2	3	4	5
8.	Computers will dehumanize society.	1	2	3	4	5
9.	Computers can teach better than teachers.	1	2	3	4	5
10.	Computers are beyond the understanding of the typical person.	1	2	3	4	5
11.	Computers will replace low-skill jobs.	1	2	3	4	5

Scale from *Computer Attitudes Factor Structure* developed by Bannon, Susan H., Marshall, Jon C., and Fluegal, Susan in Cognitive and affective computer attitude scales: A validity study. *Educational and Psychological Measurement, 45*, 679-681.

Ease of Use Attitude Survey

Name: _____

School: _____

(*Note*: This attitude survey form could be administered concurrently with the Computer Attitudes Survey. For many teachers, their attitude toward ease of availability and access of computer software and hardware may be a major determining factor in whether they make instructional use of computers for themselves and their students. Note, however, that if use of this form in a summative evaluation detects a change in teacher attitude over time, the change may not necessarily be related to the inservice. For example, it could be that the teacher's school purchased a lot more computers!)

Instructions:
The following activities relate to the ease of using computers and software in your curriculum and classroom. For numbers 1-7, please circle the number that **best** describes your attitude towards each activity. The scale runs from 1 (Very Difficult) to 5 (Very Easy).

		Very Difficult				Very Easy
1.	Obtaining a computer and monitor for use in my class is	1	2	3	4	5
2.	Obtaining the proper software is	1	2	3	4	5
3.	Scheduling the use of the computer lab for my class is	1	2	3	4	5
4.	Obtaining time for setting up the computer in my class is	1	2	3	4	5
5.	Obtaining time for learning how to use and review new software is	1	2	3	4	5
6.	Obtaining time for using the computer within the present curriculum is	1	2	3	4	5
7.	Using a computer and software in my class is	1	2	3	4	5

8. The number of machines available for use in my classroom is _____.

9. The number of teacher(s) who share the available machines is _____.

Inservice Participant Focused Interview
(Long form, for an in-depth interview.)

Site: _____ Date: _____

Subject: _____ Researcher: _____

Introduction

Purpose	This interview is part of the computer inservice follow-up. The interview is a major source of data to help us determine the residual effect of the inservice you completed.
Topics to be covered	Interview questions will briefly cover the following topics: your teaching experience, your experience with computers, features of the inservice, your attitude and expectations about using computers in education, and how completing the inservice affected you. If there is time available at the end of the interview, please feel free to go back and provide more detail on specific questions.
Ethics	I would like to tape record this interview only for the purpose of validating the accuracy of my questions. The taped interview will be heard by only myself and "X" (list and other names and explain why they may also listen to the recording). Your name will never be mentioned, nor will any particular response be connected to you. In addition, you may turn the tape recorded off at any time.
Concerns of respondent	Do you have any questions or concerns before I begin?

Experience (Time allocation 5 min.)____

Teaching — How long have you been teaching (brief)?

Computers — Briefly describe your experience with computers.

If experienced, what brands of computers do you feel ***comfortable*** using?

___ Apple
___ Atari
___ Commadore (PET)
___ Macintosh
___ IBM
___ Radio Shack
___ Other (Note Brand)
___ Other (Note Brand)

Inservice Features (Time Allocation 5-7 min.)

Content — What did you perceive as the ***subject*** of the inservice you completed?

Positive features — What were the ***features*** that made the inservice work best for you? Examples?

(As a backup, show list of inservice features and ask: Do you remember any of these features?)

Limitations — What ***features*** of the inservice ***limited*** its success?

(As a backup, show list of features and ask: Others say these features are the most important, what would you add or delete? Did your inservice have these?)

Changes over time

Would your answers have been different just after you finished the inservice?

Attitudes and Expectations

(Time allocation 10 min.)

Computers in education

What do you think we should be doing with computers in education?

Probe to elicit teachers' perceptions in the following areas: appropriate uses of computers

____ enrichment ____ remediation

____ regular instruction

If time permits suggest teachers describe some specific examples of appropriate uses.

Teaching

What would you like to be doing with computers in your own classroom?

Effect on students

What effect will classroom use of computers have on your students?

How will they respond? What will they learn?

Reason for inservice

Why did you sign up for the inservice?
Was it voluntary? __ yes __ no

Anticipated Outcomes	What did you hope to learn? What did you hope to be able to do?
Outcomes	(Time allocation 15 min.)
Expectations	Did you learn what you hoped to learn? Why? Why not?
Knowledge and Skills	Describe what you learned? What facts and skills?
Teaching	Did the inservice affect the way you teach? Either how you teach or what you teach?
Students	Name the computer applications that you feel are the most beneficial to your students? (Provide only word processing as an example of a computer application.)

	Have you seen changes in your students since using computers in the class? (Possible examples: student attitude toward school, toward learning, toward subject matter.)
Plans	What do you plan to be doing with computers in the future?
Problems	What factors influence your choice to use or not use computers in your classroom? (If participants have difficulty answering this questions—suggest they think about the following: access to computers, time issues, support from school administration, etc.)
	What problems have you had trying to use computers that the inservice did not prepare you to solve?
Changes in inservice	How would you change the inservice? (Omit if time becomes a problem.)
Final Instructions	We are at the end of the interview, is there anything else you would like to mention or a question you wish to go back to? **Please thank the individual for his or her time and input and tell them they have been very helpful.**

Inservice Participant Focused Interview
(Short form, for a brief interview.)

Name: _____

School: _____

Date: _____

Instructions:

Instruct the participant to answer the following questions as briefly as possible.
(*Note*: Use the same confidentiality discussion as is given with the Long Form.)

1. Describe the purpose of the computer inservice.

2. State why you participated in the computer inservice.

3. List three changes, in you as an individual or teacher, that can be **attributed** to your participation in the computer inservice sessions.

   a)

   b)

   c)

4. Identify the three most important experiences that occurred during the training.

a)

b)

c)

5. List the **subject areas**, identified in the training, where computer use benefits **your students**.

6. List the **computer applications,** identified in training, that benefit **your students**.

7. List the **subject areas,** discussed in training, where you think computer use **benefits you**.

8. List the **computer applications,** utilized in training, that **benefit you**.

9. Do you feel you know enough about computers to make **effective** use of them in **your** teaching?

10. How has the **non-computer content** of what you teach been affected by your increasing computer knowledge?

Computer Inservice Project Long Term Assessment (Questionnaire.)

Name: _____

School: _____

Date: _____

Instructions for Part 1:
For numbers **1-9** below, please **circle** yes or no.

1. Do you still have, use, or reference the **computer inservice** handouts/materials?

2. Prior to the computer inservice, was there an in-school computer interest or support group at your school?

   YES NO

3. Following the completion of the inservice sessions, has a computer interest or support group been formed?

   YES NO

4. Have you requested that your school or department purchase any software within the last year?

   YES NO

5. Do you use the school district's software preview center?

   YES NO

6. Do you have a computer in your home? YES NO
   If you circled **YES**,

   (a) What brand and model is it?

   (b) Do you bring it into the classroom? YES NO

7. Do you plan to purchase a personal computer within the next 12 months?

   YES NO

8. Does the integration of the computer in education change the priorities of what should be taught in the curriculum?

   YES NO

9. Do you feel that you know enough about computers to make effective use of them in your teaching?

YES NO

10. (a) List the **names** of the top five computer programs/packages that you use either in your role as an educator or for personal use.

(b) Indicate the **approximate number** of computer programs/packages you use with your classes. _____

(c) Indicate the **approximate number** of computer programs/packages that are for your personal use. _____

11. List the **names** of the top five computer programs/packages (titles) that you use or have used most frequently with your students.

Instructions for Part 2:
Please answer each of the following questions with a checkmark (√) .

1. Before the inservice sessions, how involved were you in integrating computers into your curriculum?
   ___ none ___ slightly ___ somewhat ___ very

2. Since the inservice training, have you increased your involvement in the integration of computers into the curriculum?
   ___ none ___ slightly ___ moderately ___ much

3. Before the training, were you part of a local computer support group?
   ___ Yes ___ No

4. Since the training, have you been involved in starting a local computer support group or become a member of one?
   ___ Yes ___ No

5. Since the inservice sessions, have you increased you communications with others about integrating computers into the curriculum?
   ___ Yes ___ No

   If you checked "yes" to question number 5, please indicate the approximate number of people you have communicated with in each of the following categories:

Approximate Number of People	Categories
_____	Shared information with people unaware of how to integrate computers into the curriculum.
_____	Exchanged information with people already involved with integrating computers into the curriculum.
_____	Contacted other inservice session participants.

6. Have you used any of the materials you received at the inservice sessions? ___ Yes ___ No

   If you checked "yes," how useful did you generally find the materials to be? Please check one.
   ___ Useless ___ Hardly useful ___ Somewhat useful ___ Very useful

7. Do you think the type of training you received helps to promote computer integration into the curriculum? ___ Yes ___ No

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Dept. of Educational Psyhology
The University of Georgia
Athens, GA 30602

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2 : ready for service or action

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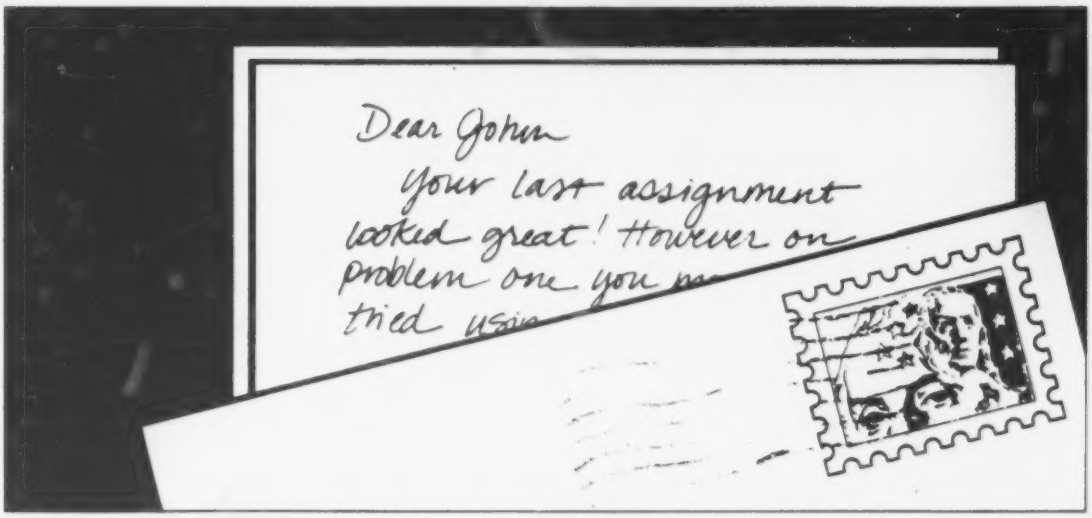

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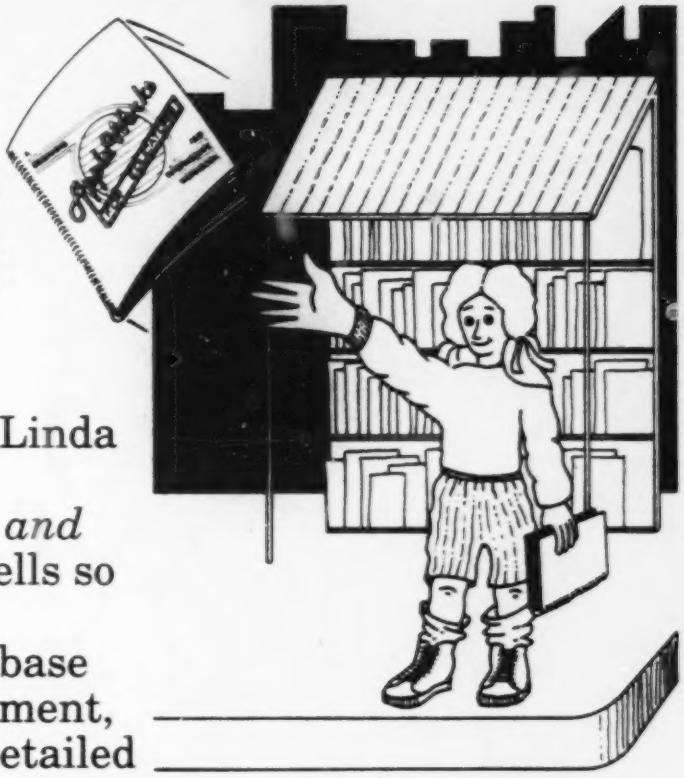

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